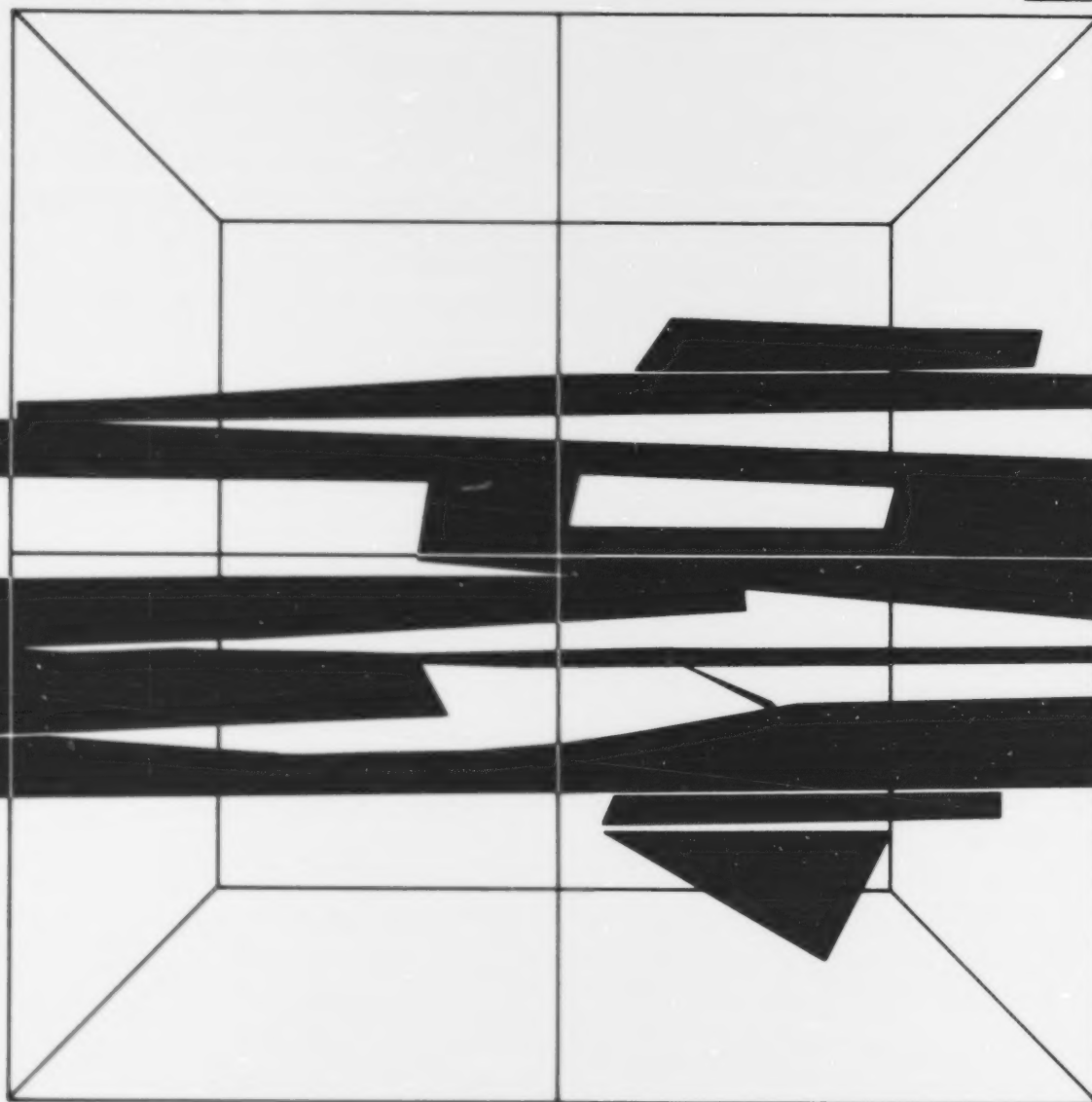


Measurement of Emissions
of Polychlorinated Dibenzop-Dioxin (PCDD)
and of Polychlorinated Dibenzofuran (PCDF)
from the Des Carrieres Incinerator
in Montreal

Report EPS 5/UP/RQ 1

December 1984



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by

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ABSTRACT

This report sets out the results of the measurements taken at the Des Carrières Municipal Incinerator in Montreal in order to determine the concentration of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in the stack gases.

The program was carried out in two steps. Gases from incinerator units 3 and 4 were sampled in November 1982, and those from unit 1 were sampled in March 1983.

Twelve samplings were done in all (four in November 1982 and eight in March 1983); the incinerator's operating conditions were maintained at values close to normal, that is at about 80% capacity.

The same methods were used for the sampling and analysis in both steps and, at the time, were considered to be the most advanced methods for such work.

The study allowed us to estimate PCDD (T₄-O₈CDD) concentrations at 500 pg/m³ and PCDF (T₄-O₈CDF) concentrations at 367 pg/m³ in the stack gases (average of 12 tests). This corresponds to annual emissions of 0,54 g PCDD and 0,39 g PCDF, considering a feed rate of waste of 275,000 metric tonnes a year.

Despite an analysis of operating conditions, it was impossible to determine why the results varied considerably from one test to another. It was also noted that the PCDD and PCDF concentrations measured at the Des Carrières Incinerator were among the lowest measured.

We prepared recommendations so as to better relate incinerator operating conditions to the PCDD and PCDF concentrations measured, in the event that other samplings were to be done.

RÉSUMÉ

Le présent rapport donne les résultats des mesures effectuées à l'incinérateur municipal Des Carrières à Montréal afin de déterminer la concentration en polychlorodibenzo-p-dioxines (PCDD) et en polychlorodibenzo-furannes (PCDF) dans les gaz de cheminée.

Le programme de mesures fut réalisé en deux étapes, la première, en novembre 1982, où le gaz échantillonné provenait des unités d'incinération 3 et 4 et la seconde, en mars 1983, où le gaz échantillonné provenait de l'unité n° 1.

Au total, douze (12) essais ont été effectués (4 en novembre 1982 et 8 en mars 1983) dans des conditions d'exploitation de l'incinérateur se rapprochant des conditions habituelles, soit à environ 80 p. cent de la capacité de l'incinérateur.

Les méthodes de prélèvement et d'analyse utilisées, jugées les plus perfectionnées au moment de leur utilisation, étaient les mêmes pour les deux séries de mesure.

Les résultats des mesures effectuées ont permis d'estimer les concentrations en PCDD (T₄-O₈CDD) à 500 pg/m³ et de PCDF (T₄-O₈CDF) à 367 pg/m³ dans les gaz de cheminée (moyenne des 12 essais). Ceci correspond à des émissions annuelles de 0,54 g de PCDD et de 0,39 g de PCDF, en considérant une alimentation en déchets du 275 000 tonnes métriques par an.

L'examen des conditions d'exploitation n'a pas permis de déterminer les raisons pour lesquelles les résultats varient de façon considérable d'un essai à l'autre. On observe aussi que les concentrations en PCDD et en PCDF mesurées à l'incinérateur Des Carrières sont parmi les plus basses à avoir été mesurées.

Des recommandations ont été formulées en vue d'établir une meilleure relation entre les conditions d'exploitation de l'incinérateur et les concentrations de PCDD et de PCDF mesurées, dans le cas où d'autres prélèvements seraient effectués.

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This report sets out the results of the measurements taken at the Des Carrières Municipal Incinerator in Montreal in order to determine the concentration of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) in the stack gases.

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L'examen des conditions d'exploitation n'a pas permis de déterminer les raisons pour lesquelles les résultats varient de façon considérable d'un essai à l'autre. On observe aussi que les concentrations en PCDD et en PCDF mesurées à l'incinérateur Des Carrières sont parmi les plus basses à avoir été mesurées.

Des recommandations ont été formulées en vue d'établir une meilleure relation entre les conditions d'exploitation de l'incinérateur et les concentrations de PCDD et de PCDF mesurées, dans le cas où d'autres prélèvements seraient effectués.



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1 INTRODUCTION

Polychlorinated dibenzo-p-dioxins (PCDD) are organic compounds whose basic molecular structure consists in two benzene rings connected by two oxygen atoms. This structure can include from one to eight chlorine atoms in eight different positions in the nucleus. Polychlorinated dibenzofurans (PCDF) are similar compounds, but whose two benzene rings are connected by a single oxygen atom. There are 75 different PCDD compounds (including isomers), and 135 PCDF compounds. Each compound is differentiated by the number of chlorine atoms and their position in the molecule.

PCDDs and PCDFs are not chemicals that we intentionally manufacture or for which we have any specific use. They are by-products (in trace amounts) formed during the production or combustion of industrial organic chemicals (1,2).

Chemical products (chlorophenols, herbicides, PCBs), various types of combustion (incineration, boilers, wood combustion, and so on), and motor vehicles are the three types of sources which release PCDDs and PCDFs into the environment.

The main concerns related to dioxins in Canada are their effects on human health, wildlife, and commercial and sport fishing. The federal government intends to concentrate its attention on the use of dioxin-containing chemicals and the elimination/disposal of wastes associated with their manufacture, as well as dioxins resulting from combustion (1).

Part of the assessment of combustion sources of dioxins in Canada is a program to measure emissions from the Des Carrières Incinerator in Montreal. The objectives of this program were to continue the evaluation of sampling and analysis methods for PCDDs and PCDFs, and to evaluate atmospheric emissions from a municipal waste incinerator, so as to obtain an emission factor which might be applicable to other incinerators in Canada.

The results of the sampling program presented in this report are expressed in quantities of tetra-, penta-, hexa-, hepta- and octachlorinated dibenzo-p-dioxins and furans. These quantities represent the total quantities of all the isomers in the samples for each of the groups. The samples were not specifically analysed for 2,3,7,8-TCDD, and therefore we cannot draw any conclusions on the presence of this compound in the samples. In reference (3), however, it is mentioned that 2,3,7,8-TCDD constitutes approximately 0.3% of total TCDDs in samples of fly ash from Canadian incinerators.

2. PROCESS

The Des Carrières Incinerator, in the City of Montreal, was built in 1970. It has four incinerator units, each consisting in a furnace, a steam generator and a gas purification system. It was designed to process 340,000 tonnes of waste a year, but in fact handles only about 275,000 tonnes in a normal year.

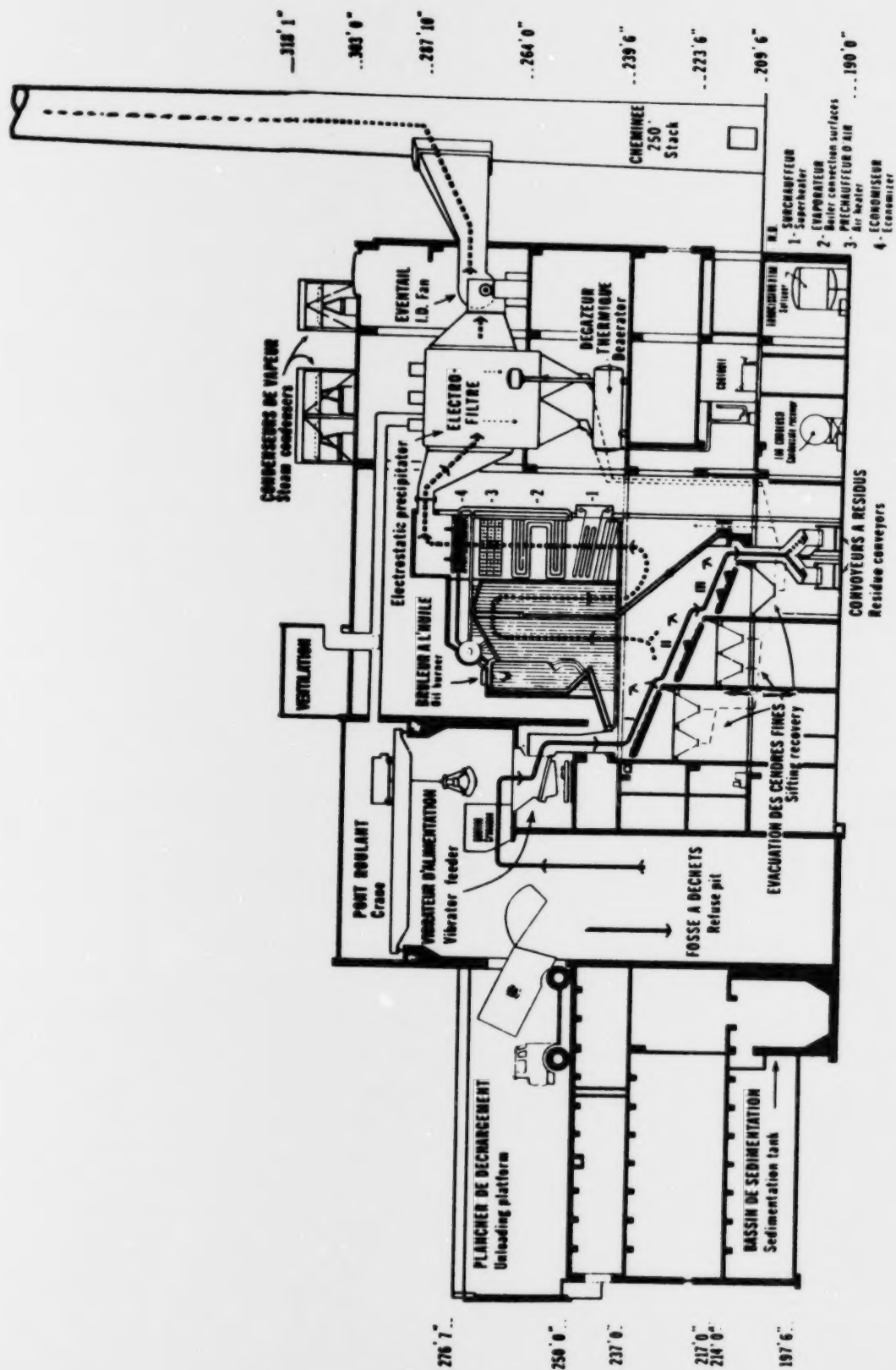
2.1 Furnaces. The rated capacity of each Von Roll furnace is 11,3 tonnes of solid waste an hour, with an overload capacity of 13,6 tonnes an hour. The furnace is illustrated in Figure 1.

The waste, stored in the pit, is fed into the furnace by means of feeding chutes equipped with vibrators to ensure a steady flow of waste. The interior of the furnace is made up of three inclined grates in cascade, with a total surface of 40 m². Each grate corresponds to one step in the incineration process, either drying and ignition, burning and finishing. The mobile parts of these grates move the combustible materials along at variable rates.

The preheated, forced combustion air is introduced under the second and third sections through hoppers used to remove residue. There is no secondary air supply.

2.2 Steam generator. Each unit is equipped with an Eckrohor-type three pass steam generator. The combustion gases from the furnace are fed into a tube evaporator with an exchange surface of 1426 m², and then to a superheater, the boiler convection surfaces, an air preheater and an economizer.

Figure 1 THE DES CARRIERES INCINERATOR IN MONTREAL



2.3 Gas processing. Each unit was formerly equipped with an electrostatic precipitator with two electrostatic fields (overall measured efficiency 85-92%) in order to capture particulates carried in the gases (see Figure 1). As of May 1982, each precipitator was replaced with a multicyclone and a three-field electrostatic precipitator with an overall design efficiency of 99.3% and a maximum load gas velocity of 0.91 m/sec (3 ft/sec).

This modernization of atmospheric emission control equipment in the incinerator was also intended to reduce HCl emissions. A lime injection system was designed whereby a set quantity of lime is added directly to the waste supply.

2.4 Disposal of residue. The ash collected from under the furnace grates and fly ash recovered by the multicyclones and electrostatic precipitators is mixed with water and fed into the residue conveyor. The residue is then loaded into trucks and taken to a sanitary landfill site. The water is fed into a sedimentation tank, and later re-used in the system.

2.5 Operation. The Des Carrières Incinerator is used almost exclusively to burn domestic waste (97% residential waste, 3% commercial waste). Large pieces of metal (home appliances, metal tanks) are sorted out and sent to a landfill site. During the tests, the furnaces operated normally. They are usually operated so as to keep the steam flow at about 36,000 kg/hour per furnace, or at approximately 80% full capacity. Within these limits, the combustion air and waste supply are varied in accordance with the type of waste and combustion, so as to keep operations as smooth as possible. The primary air supply under the second and third grate sections is controlled semi-automatically. The air supply flow is set by an operator, and maintained by an automatic control. The Des Carrières Incinerator has no secondary air supply system.

3. MEASUREMENT OF EMISSIONS

3.1 Sampling program. Two sampling series were conducted: one in November 1982 and the other in March 1983.

Four samples were taken in the first series, on November 11, 16, 18 and 19, from the west stack, which evacuates the gases from units 3 and 4, operating with the original two-field electrostatic precipitators. In each of the four tests, the samples of fly ash were taken from the hoppers of the unit 4 precipitator. This whole series of tests was conducted by a team from the Pollution Measurement Division of the EPS in Ottawa, under the supervision of Michael Bumbaco of that Division.

In the second series, two samples were taken daily on March 15, 17, 29 and 30, from the east stack which evacuates gases only from unit 1. At the time, this unit was equipped with the new gas purification system, with the multicyclone and the three-field electrostatic precipitator. The stack intake from unit 2 was carefully blocked to avoid air infiltration. During the last four tests (March 29 and 30), lime was injected at a fixed rate of 81.6 kg/hour.

The second sampling series, that is the collection and recovery of samples, was done for Environment Canada by Arthur Gordon Expertises en Environnement Ltée (AGEEL). The Contractor's team was supervised by an engineer from the Regional Office of Environment Canada. Four samples of ash (or residue) were taken from four different locations: the furnace No 1 evacuation hopper; the unit 1 multicyclone hopper; solid materials loaded into a truck for disposal at the landfill site; and solid materials floating on the surface of the sedimentation tank.

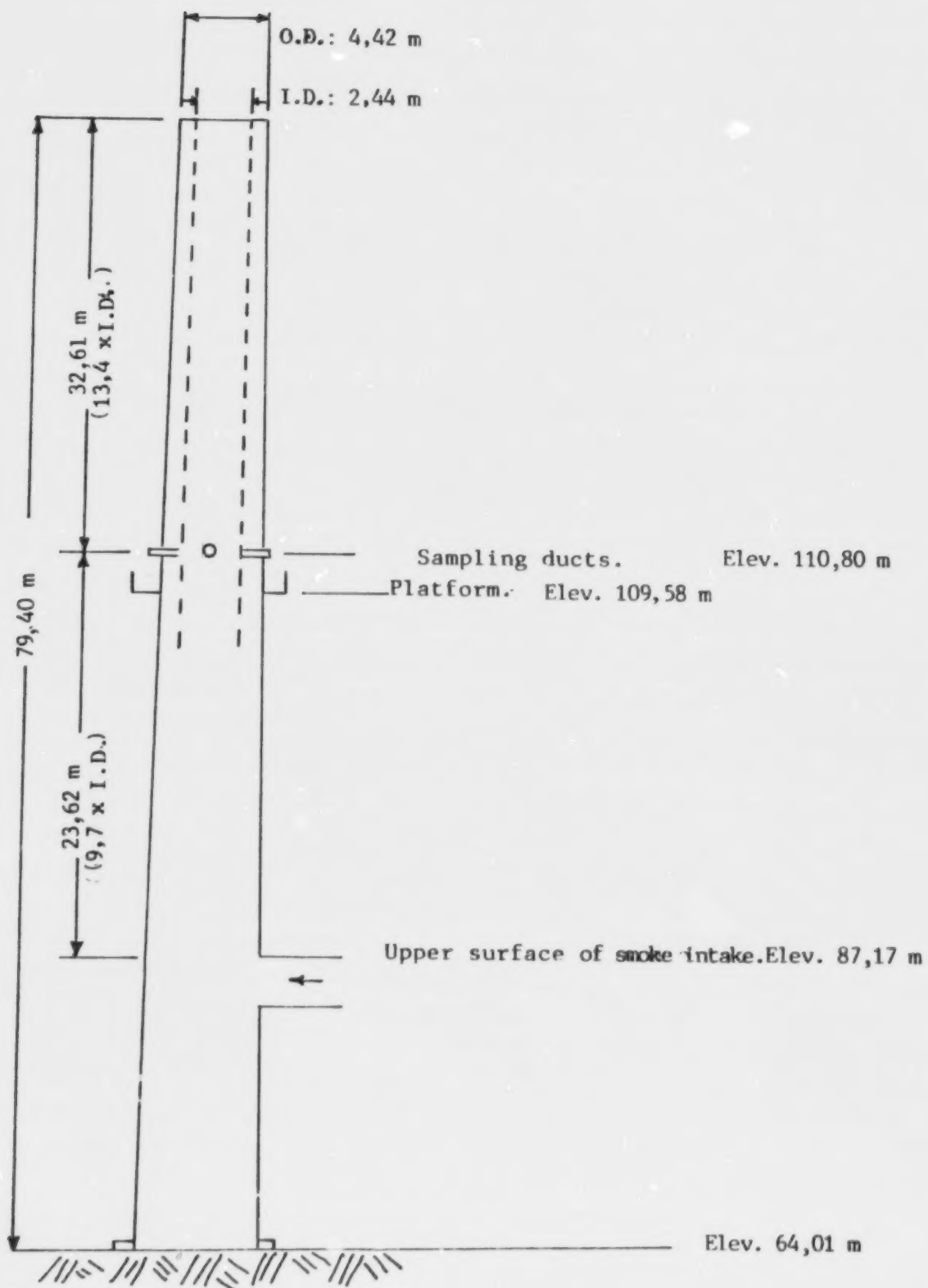
All the samples were analysed by the Analytical Services Division at the Environment Canada River Road Environmental Technology Centre in Ottawa.

3.2 Sampling sites. Samples were taken from the sampling platform in the west stack in November 1982 and from the platform in the east stack in March 1983. The total height of the two stacks is 79.40 m. The sampling ducts, four in each stack, were located equidistantly around the circumference of the stack, at a height of 46.78 m above ground level (see Figure 2). The interior diameter of the stack is a constant 2.44 m. The sampling ducts were located 9.7 diameters downstream of the turbulence caused by the incoming gas, and 13.7 diameters upstream of that caused by the stack exit.

The samples were taken from 20 points distributed around two perpendicular traverses (see Figure 2). During the sampling series in November 1982, each of the points was generally sampled for a period of 10 minutes, while readings were taken and adjustments made every five minutes so as to maintain isokinetism. The tenth point of the east-west traverse could not be sampled, however, owing to the accumulation of dust on the interior wall of the west stack. The ninth point of the traverse was therefore sampled for 20 minutes. In March 1983, when the sampling ducts in the east stack were inspected, it was noted that they projected about 5 cm into the stack, and that a considerable amount of dust had accumulated around them. For this reason, during the eight samplings done in March 1983, points 1 and 10 were not sampled, while points 2 and 9 were sampled for double the length of time.

3.3 Sampling method. The sampling method was based on EPS 1-AP-74-1, "Standard Reference Methods for Source Testing: Measurement of Emissions of Particulates from Stationary Sources". The method was altered, however, to meet the requirements associated with the sampling of dioxins and furans and to permit the capture of adequate quantities of these substances in particulate and gaseous form.

Figure 2 STACK



These modifications, initially inspired by the work done by Dow Chemical Co, were made by the group from the Pollution Measurement Division, on the basis of results of different samplings done by the group since 1980.

The sampling procedures used to collect samples from the Montreal incinerator in November 1982 and March 1983 are explained in detail in Appendix 3.

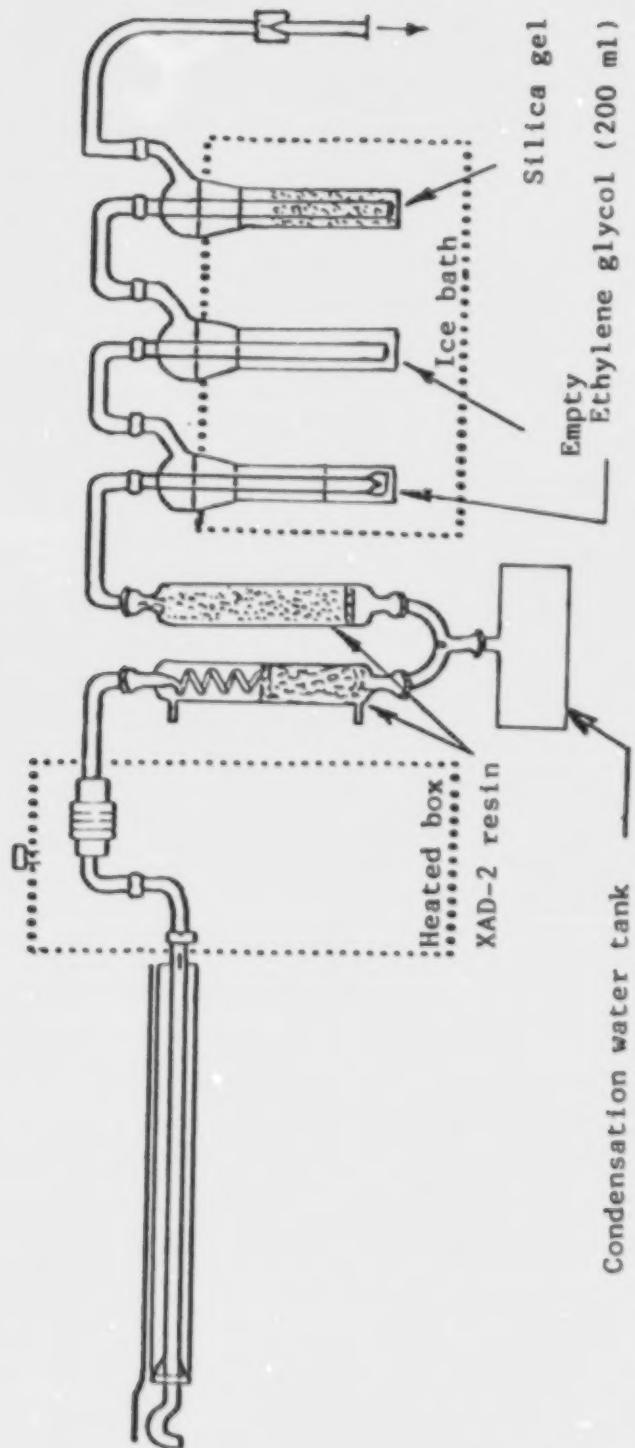
Figure 3 shows a diagram of the sampling train used. The front half of the train captures the particulates in the sample. It consists in a stainless steel probe with a nozzle of the same material, and a filter in a heated box.

The back half of the train was designed to capture PCDDs and PCDFs in gaseous form in the sample. The first condensation and adsorption unit cools the gases to a temperature below 20°C (so as to avoid decomposition of the resin). The organic products in the sample are adsorbed by the XAD-2 resin. The condensate, which has percolated across the first resin bed, where the organic products were captured, is collected at the bottom of the unit, while the gas is directed to the second bed of resin and the impingers. The first impinger contains 200 ml of ethylene glycol which captures the dioxin and furan compounds not adsorbed by the resin. The second impinger is empty, so as to avoid any overflow of ethylene glycol into the last impinger, containing silica gel. This last impinger captures any moisture still present in the gas. The units containing XAD-2 are covered with aluminum foil during the entire sampling process, so as to prevent photodegradation.

For each test, a sample of about 2 m³ of gas was taken (on a dry basis, at reference conditions of 25°C and 760 mm Hg).

So as to determine the composition of the stack gas, an integrated sample was taken for each test, and analysed using an Orsat apparatus, during the sampling series of March 1983. In November 1982, for each test, a sample of stack gas was analysed in situ by means of a Fryite apparatus.

Figure 3 SAMPLING TRAIN



3.4 Recovery of samples. Following the sampling, the train was dismantled and taken to the Capitaine Bernier Laboratory in Longueuil, where the samples were recovered by means of the procedure described in Appendix 3. For each test, eight separate samples were recovered from the different parts of the sampling train, so as to evaluate the efficiency of the train. Tables 1 and 2 summarize the distribution of the different samples taken from the sampling train for each of the sampling series. The liquid samples were placed in bottles of amber glass, and a Teflon film was placed under the normal cover, so as to ensure that the sample would not come into contact with the plastic lid. All the material used during the recovery procedure (glass bottles, Teflon film, aluminum foil) was first cleaned with solvents (quality: distilled in glass).

The filters were placed in a glass petri dish, which was covered with aluminum foil and labelled. The adsorption units containing the resin were sealed with glass plugs, covered with aluminum foil and identified.

Table 1 DISTRIBUTION OF SAMPLES IN THE SAMPLING TRAIN -
november 1982

	Sample	Description	Procedure
Front half	1	Nozzle, probe, front half of filter holder	Brush and wash with acetone, iso-octane, methanol and me- thylene chloride. Collect the liquids in an amber glass bottle.
	2	Filter	Place in a petri dish and seal, and wrap in aluminum foil.
	3	Nozzle, probe, front half of filter	Rinse with acetone, methanol and methylene chloride, and collect in an amber glass bottle
Back half	4	Condensation and adsorption unit	Seal with glass plugs and wrap in aluminum foil.
	5	Adsorption unit	Seal with glass plugs and wrap in aluminum foil.
	6	Condensation water tank and connectors	Contents and rinse with iso- octane, and collect in an am- ber glass bottle.
	7	First two impingers and connectors	Contents and rinse with ethy- lene glycol and water, and collect in an amber glass bottle.
	8	Glassware of back half of train	Rinse with acetone, methanol and methylene chloride, and collect in an amber glass bottle.

Table 2 DISTRIBUTION OF SAMPLES IN THE SAMPLING TRAIN -
march 1983

Sample	Description	Procedure
Front half	1 Nozzle, probe, front section of filter holder	Brush and wash with methanol iso-octane, and methylene chloride. Collect the liquids in an amber glass bottle.
	2 Filter	Place in a petri dish and seal, and wrap in aluminum foil.
	3 Nozzle, probe, front half holder	Rinse with methanol, iso-octane, and methylene chloride, and collect in an amber glass bottle.
Back half	4 Condensation and adsorption unit	Seal with glass plugs and wrap in aluminum foil.
	5 Adsorption unit	Seal with glass plugs and wrap in aluminum foil.
	6 Condensation water tank and connectors	Contents and rinse with distilled water and iso-octane, and collect in an amber glass bottle.
	7 First two impingers and connectors	Contents and rinse with distilled water and iso-octane, and collect in an amber glass bottle.
	8 Glassware of back half of train	Rinse with methanol, iso-octane and methylene chloride, and collect in an amber glass bottle.

4. ANALYSIS The samples recovered from the different parts of the sampling train were sent to the Environment Canada Analytical Services Division Laboratory, in Ottawa, where they were kept at 2°C in the dark, so as to prevent any degradation prior to analysis.

Appendix 5 gives a detailed description of the analysis method used to assess the PCDD and PCDF content of samples taken in November 1982 and March 1983.

The samples containing solid material (ash, filters) were soxhlet-extracted with toluene for 16 to 24 hours. The liquid samples were extracted with methylene chloride, in separator funnel. The product of these extractions was then concentrated to about 1 ml, and passed through three chromatographic columns, so as to remove substances other than PCDDs and PCDFs from the samples and thereby limit interference during the analysis.

The purified sample was then analysed for its PCDD and PCDF content, using a GC/MS (gas chromatograph/mass spectrometer - Finnigan 4500).

5. RESULTS

5.1 Incinerator operation. Different data were compiled at regular intervals during the sampling process so as to monitor the operation of the combustion unit or units sampled. The data are set out in Appendices 1 and 2.

The quantity of waste burned in the furnaces every hour during the tests was calculated on the basis of the amount of steam produced. The persons in charge of the incinerator provided us with a weekly conversion factor corresponding to the different times of the tests, and these factors were used to obtain the hourly waste feed rate.

The weekly factors used were 2,39 kg steam produced/kg of waste, for the first test (November 11, 1982); 2,90 kg steam/kg of waste for tests 2, 3 and 4 (November 16, 18 and 19, 1982); 2,44 kg steam/kg of waste for tests 1, 2, 3, and 4 (March 15 and 17, 1983) and 2,87 kg steam/kg of waste for tests 5, 6, 7 and 8 (March 29 and 30, 1983).

During the November sampling, the mean flow of steam produced was 33 439 kg/hr for unit 3, and 34 540 kg/hr for unit 4. This corresponds to an average supply of 22,66 tonnes/hr of waste for the two units. For the sampling in March, the mean steam production was 36 215 kg/hr for unit 1, corresponding to an average supply of 12,07 tonnes/hr of waste.

The furnace temperature (average for each test) and the supply rate of waste are shown in Tables 3 and 4. The temperature was measured in the top of the furnace chamber, and could be read in the incinerator control room.

In November, the average temperature of furnace No 3 was 693°C, and that of furnace No 4, 707°C. During the March sampling, the average temperature of furnace No 1 was 789°C.

The last four tests of March 1983 took place while lime was being injected into the waste feed at a fixed rate of 81,6 kg/hr.

Table 3 DATA ON INCINERATOR OPERATION*

(November 1982)¹

Test	Date	Average furnace temperature		Mean steam production		Total supply (tonnes/hr)
		Furnace 3 (°C)	Furnace 4 (°C)	Furnace 3 (kg/hr)	Furnace 4 (kg/hr)	
1	11-11-82	688	694	32 850	33 490	27,76
2	16-11-82	696	730	33 015	34 560	23,30
3	18-11-82	681	676	32 900	34 960	23,40
4	19-11-82	706	729	34 990	35 150	24,19
Average		693	707	33 439	34 540	24,66

* Average over the duration of the sampling

1 Prior to modifications to emission control system

Table 4 DATA ON INCINERATOR OPERATION*

(March 1983)¹

Test	Date	Average temp of Furnace 1 (°C)	Average steam production (kg/hr)	Supply (tonnes/hr)	Lime injection (kg/hr)
1	15-03-83	770	35 925	14,72	-
2	15-03-83	768	36 023	14,76	-
3	17-03-83	768	33 252	13,63	-
4	17-03-83	813	37 682	15,44	-
5	29-03-83	781	35 769	12,46	81,6
6	29-03-83	790	36 650	12,77	81,6
7	30-03-83	799	38 002	13,24	81,6
8	30-03-83	823	36 419	12,69	81,6
Average		789	36 215	13,71	

* Average over duration of sampling

¹ After modifications to emission control system

On the basis of these data, it can be seen that the furnaces were generally operated under similar conditions from one test to another. It is worth noting, however, that in November 1982 the average temperature of the furnaces was less than that measured in furnace No 1 during the tests in March 1983.

5.2 Stack conditions at time of sampling. Tables 5 and 6 show a summary of the results of the sampling. For both series of tests, the percentage of isokineticism obtained was within the margin of 10%, showing that the sampling velocity corresponded that the sampling velocity corresponded acceptably to the stack gas velocity. When comparing Tables 5 and 6, it must be remembered that during the sampling of November 1982, two units were operating and evacuating their combustion gas into the stack sampled (west stack), whereas in March 1983, only unit 1 was in operation, and evacuated its combustion gases to the stack sampled (east stack).

For each of the tests, a volume of about 2 m³ of gas (at reference conditions) was taken as a sample. In November, the average stack gas velocity was 18,66 m/sec, the mean volumetric flow rate was 150,420 m³/hr, and the average stack temperature was 225°C. The mean proportion of water vapour in the gas was 16,4%.

In March, the average velocity was 9,01 m/sec, and the mean volumetric flow rate was 78,742 m³/hr. The average temperature and water vapour content of the gas were 210°C and 15,9%, respectively.

Table 5 SUMMARY OF SAMPLING RESULTS DES CARRIÈRES INCINERATOR - MONTREAL

(November 1982)

Test	1	2	3	4
Date	Nov 11 1982	Nov 16 1982	Nov 18 1982	Nov 19 1982
Time	11:32 - 16:10	10:40 - 15:02	11:11 - 15:30	11:50 - 15:10
Duration of sampling (minutes)	200	200	200	200
Volume sampled (m ³)*	2,05	2,11	2,04	1,96
Isokinetism (%)	105,5	94,3	99,6	99,3
Gas velocity (m/s)	18,26	19,96	18,78	17,64
Flow rate (m ³ /hr)*	142 380	164 100	150 720	144 480
Temperature (°C)	224	226	224	225
Water vapour content (% by vol)	18,5	14,0	17,3	15,6
Analysis of CO ₂ (% dry vol)	6,4 14,9	8,0 13,0	7,5 13,0	8,5 12,0
Dry molecular weight	29,62	29,80	29,72	29,84

* Values reported on a dry basis at reference conditions (25°C and 760 mm Hg)

Table 6 SUMMARY OF SAMPLING RESULTS DES CARRIÈRES INCINERATOR - MONTREAL

(March 1983)

Test	1	2	3	4	5	6	7	8
Date	March 15 1983	March 15 1983	March 17 1983	March 17 1983	March 29 1983	March 29 1983	March 30 1983	March 30 1983
Time	9h50 - 12h47	13h46 - 16h23	8h37 - 11h19	12h19 - 15h20	9h33 - 13h03	14h32 - 17h19	9h47 - 12h29	13h24 - 16h03
Duration of sampling (minutes)	140	140	140	160	160	140	140	140
Volume sampled (m ³)*	1,96	2,03	2,02	2,08	1,98	2,00	2,03	2,08
Isokinetic (%)	99,4	101,0	100,3	102,6	102,2	101,5	100,8	98,7
Gas velocity (m/s)	9,17	9,33	9,32	8,36	7,96	9,03	9,27	9,65
Flow rate (m ³ /hr) *	79 674	81 209	81 606	71 816	68 995	79 827	81 547	85 262
Temperature (° C)	214	210	210	204	208	209	211	211
Water vapour content (% by vol)	14,8	15,3	16,2	18,8	16,7	14,9	15,7	15,0
Analysis of								
CO ₂	7,4	7,4	8,2	9,2	8,2	8,9	8,4	6,5
O ₂	11,8	11,8	11,5	10,3	11,8	10,7	11,0	12,5
CO	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Dry molecular weight	29,66	29,66	29,77	29,88	29,79	29,85	29,78	29,54

* Values reported on a dry basis at reference conditions (25°C and 760 mm Hg)

5.3 PCDD and PCDF concentrations and emissions. On the basis of the laboratory results (see Appendix 6) and the data from the sampling, the PCDD and PCDF concentration in the combustion gas of the incinerator fed into the stack was calculated for each of the tests conducted. These concentrations, expressed in pg/m^3 ref (1), were corrected to 12% CO_2 .

Tables 7 and 8 show the concentrations in pg/m^3 of PCDD and PCDF calculated for the tests in November 1982, and Tables 9 and 10 show the corresponding results for the tests in March 1983.

During each of the tests, the presence of PCDD and PCDF was detected in the combustion gas; however, the quantities detected varied greatly from one test to another. The total PCDD concentrations detected in November 1982 varied from 1,4 to 34,5 pg/m^3 , and the PCDF concentrations from 3,6 to 53,4 pg/m^3 . The average concentration for all four tests conducted in November 1982 was 12,8 pg/m^3 for PCDDs and 19.4 pg/m^3 for PCDFs.

The results of March 1983 show that PCDD and PCDF concentrations varied between 47 and 1653 pg/m^3 and 14 and 1690 pg/m^3 respectively. The average PCDD concentration for the eight tests was 745 pg/m^3 , and 542 pg/m^3 for PCDF.

These concentrations included PCDDs and PCDFs collected in solid (particulate) form and in gaseous form by the sampling train. Appendix 7 shows the results, separating the PCDDs and PCDFs collected in solid and gaseous form. In general, for all the tests, most of the PCDDs and PCDFs were found in gaseous form.

¹ Note: size of units used:

ug = 10^{-6} g (one millionth)
 ng = 10^{-9} g (one billionth)
 pg = 10^{-12} g (one trillionth)

Table 7 PCDD CONCENTRATION IN COMBUSTION GAS
(IN PARTICULATE AND GASEOUS FORM)

(november 1982)

(pg/m³ ref.(1), corrected to 12 % CO₂)

Test	1	2	3	4	Average
T ₄ CDD	N.D.(2)	N.D.	1,6	2,2	0,9
P ₅ CDD	N.D.	1,4	11,8	2,9	4,0
H ₆ CDD	1,8	N.D.	7,0	4,3	3,3
H ₇ CDD	N.D.	N.D.	8,6	2,9	2,9
O ₈ CDD	N.D.	N.D.	5,5	1,4	1,7
Total PCDD	1,8	1,4	34,5	13,7	12,8

(1) : pg = 10⁻¹²g, m³ ref: gas volume in m³ calculated on a dry basis at reference conditions (25°C et 760 mm Hg)

(2) : N.D. : not detected (detection limit: 2 pg per sample)

Table 8 PCDF CONCENTRATION IN COMBUSTION GAS
(IN PARTICULATE AND GASEOUS FORM)

(november 1982)

(pg/m³ ref.(1), corrected to 12 % CO₂)

Test	1	2	3	4	Average
T ₄ CDF	1,8	2,1	1,6	4,3	2,4
P ₅ CDF	1,8	2,8	18,8	3,6	6,8
H ₆ CDF	N.D.(2)	N.D.	14,9	3,6	4,6
H ₇ CDF	N.D.	N.D.	12,6	2,9	3,9
OCDF	N.D.	N.D.	5,5	1,4	1,7
Total PCDF	3,6	4,9	53,4	15,8	19,4

(1) : pg = 10⁻¹²g, m³ ref: gas volume in m³ calculated on a dry basis at reference conditions (25°C et 760 mm Hg)

(2) : N.D. : not detected (detection limit: 2 pg per sample)

Table 9 CONCENTRATION IN COMBUSTION GAS
(IN PARTICULATE AND GASEOUS FORM)

(March 1983)

(pg/m³ ref(1), corrected to 12 % CO₂)

Test	1	2	3	4	5	6	7	8	Average
T4CDD	320	N.D. (2)	45	70	42	113	5	122	90
P5CDD	210	N.D.	73	122	49	143	3	151	94
H6CDD	311	4	82	83	34	423	1	146	135
H7CDD	252	9	124	143	71	455	4	94	144
OCDD	323	34	621	341	177	519	44	197	282
Total PCDD	1416	47	945	759	373	1653	57	710	745

1) : pg = 10⁻¹²g, m³ ref: gas volume in m³ calculated on a dry basis at reference conditions
(25°C et 760 mm Hg)

2) : N.D. : not detected (detection limit: 2 pg per sample)

Table 10 PCDF CONCENTRATION IN COMBUSTION GAS
(IN PARTICULATE AND GASEOUS FORM)

(March 1983)

(pg/m³ ref(1), corrected to 12 % CO₂)

Test	1	2	3	4	5	6	7	8	Average
T ₄ CDF	781	N.D. (2)	30	70	39	452	10	51	179
P ₅ CDF	569	N.D.	59	106	38	375	4	78	154
H ₆ CDF	151	2	36	48	25	421	2	71	95
H ₇ CDF	111	11	49	72	45	180	3	33	63
OCDF	80	1	60	55	42	114	3	50	51
Total PCDF	1690	14	234	351	189	1542	22	283	542

(1) : pg = 10⁻¹²g, m³ ref: gas volume in m³ calculate on a dry basis at reference conditions
(25°C et 760 mm Hg)

(2) : N.D. : not detected (detection limit: 2 pg per sample)

The average ratio of total furans to total dioxins was 1.5:1 in November 1982, whereas it was 0.72:1 in March 1983.

The results, and particularly those of March, show that dioxin concentration increases with the number of chlorine atoms (octa-CDD is particularly abundant, 38% of the total on the average), while the reverse is true for the furans (tetra-CDF [33%] and penta-CDF [28%] are the most abundant).

Tables 11, 12, 13, 14, 15 and 16 show the PCDD and PCDF emissions, expressed in ng/tonne and ug/day. If the overall average of the 12 tests conducted is calculated (Table 17), it can be seen that average PCDD emissions are 1964 ng/tonne of waste burned, and PCDF emissions are 1434 ng/tonne of waste burned.

Given a supply of waste of 275,000 metric tonnes a year, annual emissions of PCDD and PCDF are 0,54 g and 0,39 g, respectively, for the incinerator.

There is no significant difference between the four last tests conducted in March 1983, during the lime injection (81.6 kg/hr), and those conducted without lime injection.

Table 11 PCDD EMISSIONS (IN PARTICULATE AND GASEOUS FORM)

(november 1982)

Test	1 (ng/tonne) (1)	(ug/day) (2)	2 (ng/tonne) (ug/day)	3 (ng/tonne) (ug/day)	4 (ng/tonne) (ug/day)
T4CDD	N.D.	N.D.	N.D.	6,3	9,1
P5CDD	N.D.	N.D.	6,7	47,3	12,2
H6CDD	5,0	3,3	N.D.	28,4	18,3
H7CDD	N.D.	N.D.	N.D.	34,8	12,2
OCDD	N.D.	N.D.	N.D.	22,1	6,1
Total PCDD	5,0	3,3	6,7	138,9	57,9

Average (Total PCDD) : 52,9 ng/tonne
29,6 ug/day (two units operating)

(1) : Average emission rate per tonne of waste burned over the duration of the test.

(2) : Daily emission rate from both units in operation during each of the tests (based on stack gas flow).

Table 12 PCDF EMISSIONS (IN PARTICULATE AND GASEOUS FORM)

(november 1982)

Test	1		2		3		4	
	(ng/tonne)	(1) (ug/day)	(2) (ug/day)	(ng/tonne)	(ug/day)	(ng/tonne)	(ug/day)	(ng/tonne)
T ₄ CDF	5,0	3,3	10,0	5,6	6,3	3,5	18,3	10,6
P ₅ CDF	5,0	3,3	13,4	7,5	75,7	42,5	15,2	8,8
H ₆ CDF	N.D.	N.D.	N.D.	N.D.	60,0	33,7	15,2	8,8
H ₇ CDF	N.D.	N.D.	N.D.	N.D.	50,6	28,4	12,2	7,1
OCDF	N.D.	N.D.	N.D.	N.D.	22,1	12,4	6,1	3,5
Total PCDF	10,0	6,6	23,4	13,1	214,7	120,5	67,0	38,8

Average (Total PCDF) : 78,8 ng/tonne
44,8 ug/day (two units operating)

(1) : Average emission rate per tonne of waste burned over the duration of the test.

(2) : Daily emission rate from both units in operation during each of the tests (based on stack gas flow).

Table 13 PCDD EMISSIONS (IN PARTICULATE AND GASEOUS FORM)
(NG/TONNE OF WASTE BURNED)

(March 1983)

Test	1	2	3	4	5	6	7	8	Average
T ₄ CDD	1065	N.D.	184	251	159	525	21	446	331
P ₅ CDD	702	N.D.	299	431	185	663	17	549	356
H ₆ CDD	1039	14	335	295	130	1959	6	533	539
H ₇ CDD	841	30	507	514	268	2114	18	343	579
OCDD	1078	114	2540	1216	667	2406	188	713	1115
Total PCDD	4725	158	3865	2707	1409	7667	250	2584	2920

Table 14 PCDF EMISSIONS (IN PARTICULATE AND GASEOUS FORM)
(ng/TONNE OF WASTE FORM)

(March 1983)

Test	1	2	3	4	5	6	7	8	Average
T ₄ CDF	2605	N.D.	124	250	145	2097	43	184	681
P ₅ CDF	1899	N.D.	243	378	145	1738	18	284	588
H ₆ CDF	503	8	145	173	98	1954	9	258	394
H ₇ CDF	371	35	202	254	168	834	15	120	250
OCDF	266	6	243	197	159	528	12	181	199
Total PCDF	5644	49	957	1252	715	7151	97	1027	2112

Table 15 PCDD EMISSIONS (IN PARTICULATE AND GASEOUS FORM)
(ug/DAY)* FROM ONE UNIT

(March 1983)

Test	1	2	3	4	5	6	7	8	Average
T ₄ CDD	376	N.D.	60	93	48	161	7	136	110
P ₅ CDD	248	N.D.	98	160	55	203	5	167	117
H ₆ CDD	367	5	109	109	39	600	2	162	174
H ₇ CDD	297	10	166	190	80	648	6	104	188
OCDD	381	41	831	451	200	737	60	217	365
Total PCDD	1669	56	1264	1003	422	2349	80	786	954

* Based on stack gas flow

Table 16 PCDF EMISSIONS (IN PARTICULATE AND GASEOUS FORM)
(ug/DAY)* FORM ONE UNIT

(March 1983)

Test	1	2	3	4	5	6	7	8	Average
T4CDF	920	N.D.	40	93	43	643	14	56	226
P5CDF	671	N.D.	80	140	43	533	6	87	195
H6CDF	178	3	47	64	29	599	3	79	125
H7CDF	131	12	66	94	50	256	5	36	81
OCDF	94	2	80	73	48	162	4	55	65
Total PCDF	1994	17	313	464	213	2193	32	313	692

* Based on stack gas flow

Table 17 PCDD AND DCDF EMISSIONS DES CARRIÈRES INCINERATOR - MONTREAL

	PCDD total (T ₄ - O ₈ CDD) (ng/tonne)	PCDD total (pg/m ³ ref) at 12% CO ₂	PCDF total (T ₄ - O ₈ CDF) (ng/tonne)	PCDF total (pg/m ³ ref) at 12% CO ₂
November 1982 (Average of 4 tests)	52,9	12,8	78,8	19,4
March 1983 (Average of 8 tests)	2920	745	2112	542
Overall average (Average of 12 tests)	1964	500	1434	367

5.4 Ash. Samples of fly ash and residues were taken at various locations in the incinerator during the tests.

During each of the tests in November, a sample of the precipitated fly ash was taken at each of the two hoppers of the electrostatic precipitator of unit 4. The results of the analysis of these samples are shown in Table 18.

The PCDD and PCDF content of the ash follows the same pattern as that observed for the samples collected in the stack, that is that dioxins with a higher number of chlorine atoms are more abundant, whereas furans with fewer chlorine atoms are the most common.

While PCDD and PCDF concentration varies greatly from one test to another for the samples collected in the stack, it remains fairly constant for the fly ash samples collected in the electrostatic precipitator.

The average PCDD and PCDF concentration in the ash collected in November was 131 ng/g and 115 ng/g, respectively.

Table 18 PCDD AND PCDF CONCENTRATIONS IN ASH SAMPLES (ng/g)

(November 1982)

Sample number Sampling date Location	17 Nov. 11 1982 Left hopper precipitator (unit 4)	18 Nov. 11 1982 Right hopper precipitator (unit 4)	27 Nov. 16 1982 Right hopper precipitator (unit 4)	28 Nov. 16 1982 Left hopper precipitator (unit 4)	38 Nov. 18 1982 Right hopper precipitator (unit 4)	39 Nov. 18 1982 Left hopper precipitator (unit 4)	48 Nov. 19 1982 Right hopper precipitator (unit 4)	49 Nov. 19 1982 Left hopper precipitator (unit 4)
T ₄ CDD	5	3	11	6	5	7	8	22
P ₅ CDD	16	4	17	11	16	11	14	8
H ₆ CDD	16	13	32	27	21	26	31	21
H ₇ CDD	25	17	34	30	28	21	37	28
O ₈ CDD	14	22	60	106	80	60	92	37
Total PCDD	76	59	154	180	150	129	182	116
T ₄ CDF	51	15	61	51	44	53	68	38
P ₅ CDF	30	9	31	29	34	22	32	7
H ₆ CDF	17	9	31	29	23	22	33	12
H ₇ CDF	8	11	17	15	16	13	18	16
O ₈ CDF	1	6	9	6	9	7	10	5
Total PCDF	107	50	149	130	126	117	161	78

In March 1983 we were unable to collect samples of precipitated fly ash, because the new electrostatic precipitator had no sampling point. Four samples of ash and residue were collected, however, at various points (although they were not always directly related to the operation of the unit sampled), so as to gain some indication of the presence of dioxins and furans. The results of the analyses of these samples are compiled in Table 19.

Sample 74 was a dry sample collected from the residue evacuation hopper of furnace No 1; analyses showed that it contained neither PCDD or PCDF (the detection limit is 2 pg per sample).

Sample 75 contained fly ash collected at the eastern hopper of the multicyclone of unit 1. The PCDD and PCDF concentrations in this sample were 12,2 pg/g and 5,4 pg/g, respectively.

Sample 73 was collected from solid materials (residues) loaded into a truck for disposal at a sanitary landfill site. These residues were from the entire incinerator, and not only unit 1. The PCDD and PCDF concentrations detected in the sample were 1,7 pg/g and 0,4 pg/g, respectively.

Sample 76 contained solid materials from the surface of the incinerator sedimentation tank. The tank contains water mixed with incineration residues and fly ash. The contents of the sample came from the entire incinerator, and could not be considered representative of operations at the time of the stack sampling. The PCDD concentration in the sample was found to be 52,6 pg/g, and the PCDF concentration, 18,2 pg/g.

On the whole, the PCDD and PCDF concentrations in the various samples taken in March were relatively low, as compared with the fly ash samples taken in November.

Table 19 PCDD AND PCDF CONCENTRATIONS IN SOLID MATERIAL (ASH) SAMPLES (pg/g)
(March 1983)

Sample number Sampling date Location	73 March 29 1983 Solid materials (residue) loaded into a truck for disposal at a landfill site	74 March 29 1983 Ash and residue collected from the furnace evacuation hopper	75 March 30 1983 Fly ash collected from the east hopper of the unit 1 multicyclone	76 March 30 1983 Solid material floating in the sedimentation tank
I ₄ CDD	N.D.	N.D.	2,2	2,7
P ₅ CDD	N.D.	N.D.	3,9	3,7
H ₆ CDD	0,3	N.D.	1,2	13,6
H ₇ CDD	0,2	N.D.	2,7	16,9
O ₈ CDD	1,2	N.D.	2,2	15,7
Total PCDD	1,7	N.D.	12,2	52,6
I ₄ CDF	N.D.	N.D.	2,4	1,8
P ₅ CDF	N.D.	N.D.	1,8	2,1
H ₆ CDF	0,1	N.D.	0,4	6,8
H ₇ CDF	0,1	N.D.	0,5	5,1
O ₈ CDF	0,2	N.D.	0,3	2,4
Total PCDF	0,4	N.D.	5,4	18,2

6. DISCUSSION

6.1 **Sampling and analysis methods.** The same method, as described in Section 3, was used for sampling in November and March. Although this method of sampling dioxins and furans was the most advanced at the time, it was still under development. It has since undergone some minor modifications which, however, are likely to have little effect on the results obtained. The sampling and recovery methods used were apparently effective in capturing all the dioxins and furans present in the gas sampled. The analysis results showed that the quantities of PCDD and PCDF captured by the second adsorption unit (when the resin in that unit was analysed separately) were very low, and most often not detectable (detection limit of 2 pg/sample). In addition, we found very few or no dioxins or furans in the final rinsing liquid of the glassware in the sampling train (when this sample was analysed separately). This shows that the method used was generally efficient in recovering all the compounds captured by the sampling train.

It appears, however, that this method does not allow us to obtain the exact ratio in the stack gas between PCDDs and PCDFs in particulate and gaseous form. Although particulates ($>0.3 \mu\text{m}$) were captured in the front half of the train, it is possible that a proportion of the compounds in gaseous form were also adsorbed in the same section of the train (on the walls of the nozzle or the probe, or on the filter).

The analysis method described in Appendix 5 is that used to analyse the samples taken in November 1982 and March 1983. This method is considered the best and the most advanced at this time for determining PCDD and PCDF content.

Studies have been done to find the recovery rate of this method. It was found that the rate was 71% for resin samples, for example (see Appendix 5, p 17). The results in this report have not been corrected to take account of the recovery rate.

So as to verify the quality of the analyses done at the River Road Laboratory, some samples were analysed by a private laboratory, including two samples of fly ash from the Des Carrières Incinerator in Montreal. Table 20 compares the results obtained by the two laboratories. In view of the size of the quantities involved, the results of the two laboratories are quite similar, with an average discrepancy of less than 14%.

6.2 Incinerator operation. As we have seen, PCDD and PCDF concentrations in the combustion gases sampled in November 1982 were much lower than those taken from the combustion gas in March 1983. Various factors must be considered, however, before the results of the two series are compared.

1° Sampling took place during two different seasons.
The literature mentions that the composition and water vapour content of municipal waste can vary greatly from one season to another, with corresponding variations in its dioxin and furan content (4).

2° The combustion gas sampled was from different incineration units.

In November, the combustion gas was from units 3 and 4, while in March it was from unit 1 only.

It appears that the results of measurement of emissions from different incineration units cannot be compared, according to the experts (5). Although the units are the same type and design, there may have been an influx of air which altered the operation of the furnace, particularly since these units have been operating for over ten years.

3° In statistical terms, the number of samples taken is insufficient to establish any correlation.

Table 20 QUALITY CONTROL: PCDD AND PCDF CONTENT (ng/g) OF ASH SAMPLES

Sample Laboratory	17		48	
	River Road	Wellington	River Road	Wellington
T ₄ CDD	5	7,9	8	6,2
P ₅ CDD	16	19,5	14	12,3
H ₆ CDD	16	19,3	31	26,8
H ₇ CDD	25	27,0	37	39,6
O ₈ CDD	14	19,9	92	97,9
Total PCDD	76	93,6	182	182,8
T ₄ CDF	51	58,8	68	57,0
P ₅ CDF	30	38,0	32	35,1
H ₆ CDF	17	20,1	33	25,0
H ₇ CDF	8	9,8	18	16,3
O ₈ CDF	1	2,3	10	9,6
Total PCDF	107	129,0	161	143,0

6.3 Results. Although the data compiled during the sampling were analysed, it was impossible to determine the reasons for the considerable variation in the results from one sampling to another, and why, on the whole, PCDD and PCDF concentrations measured in the stack gases of the Des Carrières Incinerator are among the lowest measured.

Table 21 shows dioxin and furan emissions from various incinerators around the world, taken from a number of sources. A comparison of these data with the results we obtained for the Des Carrières Incinerator (PCDD - 500 pg/m³, PCDF - 367 pg/m³) clearly shows that the latter are much lower, by a factor of about 1000. Although the different methods used and the operating conditions of the incinerators whose results are given in Table 21 have not been analysed, the difference observed remains considerable.

Table 22 summarizes the data taken from "Dioxins in Canada: the Federal Approach", prepared by the Interdepartmental Committee on Toxic Chemicals, on the estimated quantities of dioxins entering the Canadian environment. It is estimated that the quantities of dioxins emitted from municipal incinerators could be from 1 to 50 kg a year (see Table 22).

Table 21 PCDD AND PCDF EMISSIONS MEASURED AT DIFFERENT INCINERATORS

Location	Emission in combustion gases		Reference
	PCDD (T4-O8CDD) (ng/m ³)	PCDF (T4-O8CDF) (ng/m ³)	
Montreal (Des Carrières)	0,5 (diff., 0,001 - 1,6)	0,4 (diff., 0,004 - 1,7)	
Italy (average of 6 incinerators)	10 500	2 177	(6)
United States	35	173	(7)
Italy (Valmadrera)	1 104	1 212	(4)
Hamilton, Ont. (SWARU)	2 690	6 150	(8)
United States	4 250	8 370	(9)

Table 22 ESTIMATED QUANTITIES OF DIOXINS ENTERING THE
CANADIAN ENVIRONMENT EACH YEAR

ref "Dioxins in Canada: the federal Approach"

Sources	Quantities
Use of 2,4-D	9,2 kg
Use of pentachlorophenol	1 500 kg
Municipal incinerators	
- Quantities in precipitated fly ash	6,7 kg
- Quantities emitted	6,7 kg (between 1 kg et 50 kg)
Other incineration sources	
Residual sludge	4 - 13 kg
Forest fires	160 kg

7. CONCLUSIONS AND RECOMMENDATIONS

On the basis of measurements taken at the Des Carrières Incinerator in Montreal, PCDD (T₄-O₈CDD) emissions from the incinerator were estimated at 1.96 ug/tonne of waste, and PCDF (T₄-O₈CDF) emissions at 1.43 ug/tonne of waste (average of 12 tests). These values are quite low, if they are compared with measurements from other incinerators around the world.

The sampling and analysis methods used were considered satisfactory and produced reliable results, even though the sampling method was still under development and has since been improved somewhat.

The results obtained for the sampling done in March fail to show that the injection of lime at a rate of 81,6 kg/hr has any effect on PCDD and PCDF emissions.

Given the relatively few tests conducted, statistically speaking, and the little information on the effect of varying operating conditions on PCDD and PCDF emissions, we were unable to draw many conclusions to explain the variations among the different results.

Therefore, we recommend that in the event of any future tests:

1. the various operating parameters which could influence PCDD and PCDF emissions be clearly identified and properly measured;
2. the various tests be conducted on the same incinerator units so as to make comparisons possible;
3. samples be taken of the wastes feeding the units sampled so as to assess their PCDD and PCDF content.

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APPENDIX 1

INCINERATOR OPERATING CONDITIONS

NOVEMBER 1982 SAMPLING

Incinerator operating conditions

Test No 1

Furnace No 3

time	Steam pressure (lbs/in ²)	Steam temperature (° F)	Steam flow rate (lbs/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 % damper opening	Air flow rate zone 4 % damper opening	Air flow rate zone 5 % damper opening	Total air flow rate (ft ³ /min.)	Furnace temperature (° F)
10:00	235	470	82 000	638 272	11	45	35	30	24 000	1 260
10:30	230	490	78 000	638 303	12½	40	40	30	25 000	1 260
11:03	230	455	52 000	638 337	13	60	50	30	27 000	1 180
11:40	230	450	65 000	638 372	14	50	46	31	27 000	1 240
12:02	235	470	78 000	638 394	12	40	40	30	24 000	1 275
12:25	225	450	50 000	638 418	12	50	50	30	27 000	1 260
12:48	235	475	81 000	638 440	11	45	50	30	26 000	1 290
13:10	238	475	64 000	638 463	13	40	50	30	26 000	1 320
13:42	220	430	68 000	638 498	12	50	50	30	26 000	1 380
14:05	240	480	75 000	638 520	12	40	50	30	26 000	1 260
14:31	240	475	83 000	638 546	12	35	50	30	25 000	1 250
14:50	240	490	88 000	638 565	11	35	40	30	24 000	1 260
15:11	240	480	67 000	638 584	12	50	50	30	27 000	1 220
15:35	240	485	80 000	638 610	12	40	35	30	24 000	1 270
15:55	240	480	76 000	638 630	12	50	45	30	26 000	1 280
16:16	235	470	72 000	638 652	12	42	34	30	24 000	1 290

Date: 82-11-11

* Multiply by 1 200 lbs/hr

Incinerator operating conditions

Test No 1

Furnace No 4

time	Steam pressure (lbe/in ²)	Steam temperature (° F)	Steam flow rate (lbe/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 % damper opening	Air flow rate zone 4 % damper opening	Air flow rate zone 5 % damper opening	Total air flow rate (ft ³ /min.)	Furnace temperature (°F)
10:00	230	450	80 000	491 742	10	44	65	30	21 000	1 290
10:32	230	435	79 000	491 773	10½	55	76	20	23 000	1 250
11:05	245	460	86 000	491 809	7	60	72	20	23 000	1 270
11:41	230	440	81 000	491 846	10	62	72	20	23 000	1 300
12:03	235	450	81 000	491 870	10	34	70	20	21 000	1 320
12:27	235	445	81 000	491 893	9	56	70	20	23 000	1 260
12:49	235	445	56 000	491 915	10	66	76	20	24 000	1 250
13:11	245	460	82 000	491 937	8	65	80	20	24 000	1 260
13:44	230	440	75 000	491 972	10	40	65	20	21 000	1 240
14:06	245	465	80 000	491 993	9	65	65	20	23 000	1 270
14:32	230	440	68 000	492 021	12	60	70	20	23 000	1 290
14:52	230	460	84 000	492 042	9	40	75	20	22 000	1 300
15:12	240	460	80 000	492 063	10	60	75	20	23 000	1 240
15:37	240	460	86 000	492 088	8	45	70	20	22 000	1 320
15:57	240	510	76 000	492 107	10	60	70	20	22 000	1 290
16:18	235	450	78 000	492 130	10	52	65	20	22 000	1 320

Date: 82-11-11

* Multiply by 1 200 lbe/hr

Characteristics of electrofilters

Test No 1
Furnace No 3

	Input field		Secondary		Output field		Secondary	
	Primary		MA, D.C.		Primary		MA, D.C.	
	Volt A.C.	AMP. A.C.			VOLT A.C.	AMP. A.C.		
10:08	210	28	180		210	35	210	
10:38	210	32	190		210	36	215	
11:11	210	29	180		200	36	220	
11:51	210	31	190		205	36	220	
12:12	210	30	190		210	36	215	
12:31	220	31	190		200	36	225	
12:54	200	31	180		200	36	220	
13:24	200	30	185		200	35½	220	
13:50	190	30	195		200	35½	215	
14:10	195	30	170		210	36	210	
14:37	210	32	200		205	36	225	
14:57	200	30	180		200	36	225	
15:18	210	31	190		200	36	225	
15:42	210	30	190		205	36	225	
16:02	210	32	190		205	36	225	
16:21	210	30	180		210	36	225	

Date: 82-11-11

Incinerator operating conditions

Test No 1

Furnace No 4

	Input field		Secondary		Output field		Secondary
	Primary		MA. D.C.		Primary		
	Volt A.C.	AMP. A.C.		MA. D.C.	VOLT A.C.	AMP. A.C.	MA. D.C.
10:09	215	32		200	215	37	230
10:39	225	33		205	215	37	240
11:12	220	33		200	205	37	235
11:52	230	34		225	200	37	235
12:13	210	33		190	215	37	235
12:33	230	34		200	210	37	230
12:55	220	33		200	220	37½	235
13:25	220	34		210	200	37	235
13:51	220	31		200	215	37½	240
14:11	230	34		215	215	37	240
14:36	225	34		210	210	37	240
14:58	215	32		195	210	37½	235
15:19	225	35		210	200	37	240
15:43	210	33		190	215	37½	235
16:03	245	33½		220	215	37	240
16:22	235	34		210	205	37½	240

Date: 82-11-11

Incinerator operating conditions

Test No 2

Furnace No 3

time	Steam pressure (lbs/in ²)	Steam temperature (° F)	Steam flow rate (lbs/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 % damper opening	Air flow rate zone 4 % damper opening	Air flow rate zone 5 % damper opening	Total air flow rate (ft ³ /min.)	Furnace temperature (°F)
10:00	232	485	72 000	647 254	12	54	54	40	29 000	1 300
10:30	225	485	68 000	647 284	13	64	64	40	30 000	1 300
11:02	230	490	65 000	647 316	13	58	57	41	29 000	1 290
11:30	240	485	90 000	647 346	10	49	49	42	28 000	1 300
12:00	240	490	85 000	647 376	12	45	50	41	28 000	1 200
12:30	225	475	70 000	647 405	13	47	49	41	27 000	1 240
13:02	240	485	84 000	647 436	12	54	49	41	28 000	1 320
13:44	235	490	73 000	647 479	12	52	57	38	28 000	1 310
14:00	225	485	67 000	647 495	12	58	58	38	29 000	1 260
14:34	240	485	84 000	647 531	12	60	58	37	29 000	1 320
15:05	230	480	76 000	647 562	12	60	59	37	29 000	1 300

Date: 82-11-17

* Multiply by 1 200 lbs/hr

Incinerator operating conditions
Test No 2
Furnace No 4

time	Steam pressure (lbs/in ²)	Steam temperature (° F)	Steam flow rate (lbs/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 % damper opening	Air flow rate zone 4 % damper opening	Air flow rate zone 5 % damper opening	Total air flow rate (ft ³ /min.)	Furnace temperature (°F)
10:02	240	500	75 000	500 802	10	74	75	47	26 000	1 310
10:32	230	490	80 000	500 832	10½	74	77	47	26 000	1 335
11:03	240	500	84 000	500 866	10	56	62	47	24 000	1 360
11:32	240	500	80 000	500 895	10	59	70	48	25 000	1 350
12:02	240	495	93 000	500 930	10½	52	53	47	23 000	1 400
12:32	230	495	71 000	500 961	10	67	59	47	24 000	1 330
13:04	240	500	84 000	500 996	10	67	59	47	24 000	1 360
13:45	240	495	78 000	501 037	10	65	76	47	26 000	1 340
14:02	230	490	70 000	501 054	10	65	76	47	26 000	1 340
14:36	240	500	72 000	501 084	10	68	78	48	26 000	1 300
15:07	230	500	73 000	501 123	10	71	76	47	26 000	1 340

Date: 82-11-17

* Multiply by 1 200 lbs/hr

Characteristics of electrofilters

Test No 2
Furnace No 3

	Input field		Output field		Secondary	
	Primary	Secondary	Primary	Secondary	MA. D.C.	MA. D.C.
	Volt A.C.	AMP. A.C.	VOLT A.C.	AMP. A.C.		
10:10	200	30	205	35	170	220
10:39	200	31	205	36	190	225
11:09	210	31	200	36	200	220
11:38	190	30	195	35	180	220
12:08	200	33	195	36½	200	215
12:39	200	31	200	35	205	220
13:14	210	30	205	36½	200	230
13:50	210	29	200	36½	195	230
14:08	200	31	205	36½	180	230
14:39	210	31	200	36½	180	215
15:12	210	31	205	36	185	220

Date: 82-11-17

Characteristics of electrofilters

Test No 2

Furnace No 4

	Input field		Secondary		Output field		Secondary
	Primary		MA. D.C.		Primary		
	Volt A.C.	AMP. A.C.		MA. D.C.	VOLT A.C.	AMP. A.C.	MA. D.C.
10:10	205	31	190		210	37	230
10:40	200	31	190		215	37	235
11:09	220	34	210		220	37	235
11:39	211	32	195		215	37½	240
12:09	220	34	210		210	38	235
12:40	225	34	200		220	38	245
13:15	220	33	200		220	38	240
13:52	200	32	210		220	37½	245
14:09	210	32	200		215	38	245
14:39	205	31	190		220	38	240
15:12	210	33	185		220	38	240

Date: 02-11-17

Incinerators operating conditions

Test No 3

Furnace No 3

time	Steam pressure (lbs/in ²)	Steam temperature (° F)	Steam flow rate (lbs/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 % damper opening	Air flow rate zone 4 % damper opening	Air flow rate zone 5 % damper opening	Total air flow rate (ft ³ /min.)	Furnace temperature (° F)
9:37	225	485	60 000	648 726	15	62	61	39	29 000	1 300
10:00	230	485	81 000	648 749	12	50	51	39	27 000	1 260
10:30	225	485	60 000	648 779	14	60	61	39	29 000	1 260
11:00	225	485	61 000	648 810	13	57	56	39	28 000	1 250
11:32	230	485	68 000	648 881	13	60	60	39	29 000	1 220
12:01	235	485	61 000	648 867	13	59	57	39	28 000	1 200
12:35	240	485	78 000	648 902	12	43	60	39	27 000	1 270
13:05	240	490	80 000	648 935	13	56	62	39	28 000	1 300
13:31	230	490	72 000	648 961	12	57	58	39	28 000	1 260
14:00	235	490	72 000	648 993	13	52	52	39	28 000	1 310
14:31	230	485	69 000	649 026	12	56	59	39	29 000	1 290
15:01	235	490	68 000	649 054	13	59	59	39	28 000	1 240
15:30	230	485	71 000	649 082	13	59	59	39	28 000	1 240

Date: 82-11-18

* Multiply by 1 200 lbs/hr

Incinerator operating conditions

Test No 3

Furnace No 4

time	Steam pressure (lba/in ²)	Steam temperature (° F)	Steam flow rate (lba/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 % damper opening	Air flow rate zone 4 % damper opening	Air flow rate zone 5 % damper opening	Total air flow rate (ft ³ /min.)	Furnace temperature (° F)
9:39	230	495	76 000	502 271	10	60	50	50	24 000	1 295
10:01	235	500	78 000	502 296	10	71	70	50	26 000	1 250
10:31	230	500	72 000	502 326	10	66	68	50	26 000	1 200
11:02	230	500	76 000	502 357	10	61	60	40	24 000	1 220
11:35	235	500	88 000	502 392	9	52	55	50	23 000	1 210
12:02	240	500	78 000	502 420	10	70	72	50	26 000	1 180
12:37	240	500	82 000	502 457	10	45	61	50	23 000	1 220
13:07	245	500	87 000	502 489	10	58	60	50	24 000	1 280
13:33	235	500	80 000	502 516	10	52	53	50	23 000	1 220
14:02	235	495	80 000	502 551	10	52	53	50	22 000	1 350
14:33	230	500	72 000	502 584	12	68	72	50	26 000	1 260
15:02	240	505	82 000	502 613	9	70	73	50	26 000	1 250
15:31	230	500	70 000	502 646	11	65	67	50	26 000	1 300

Date: 82-11-18

* Multiply by 1 200 lba/hr

Characteristics of electrofilters

Test No 3

Furnace No 3

	Input field		Secondary		Output field		Secondary
	Primary		MA. D.C.		Primary		
	Volt A.C.	AMP. A.C.	MA. D.C.		VOLT A.C.	AMP. A.C.	MA. D.C.
9:46	210	30	200		215	36½	220
10:10	210	31	180		215	36	225
10:38	200	30	190		220	36	225
11:07	200	30	200		205	36	225
11:39	190	30	190		200	36	220
12:07	210	32	200		200	36½	220
12:50	210	32	200		205	36½	225
13:18	215	30	215		210	36½	230
13:40	215	30	180		210	36½	215
14:07	210	31	190		200	36½	230
14:38	210	31	190		200	36½	225
15:08	210	30	185		205	36½	225
15:37	215	30	210		205	36½	215

Date: 82-11-18

Characteristics of electrofilters

Test No 3

Furnace No 4

	Input field		Secondary		Output field		Secondary
	Primary	Volt A.C.	AMP. A.C.	MA. D.C.	Primary	VOLT A.C.	MA. D.C.
9:47	225		34	210	225	37	235
10:10	220		34½	200	210	37½	240
10:39	220		33	215	225	37½	240
11:00	230		34	200	225	37½	240
11:40	225		33	205	215	37½	240
12:08	230		33	210	215	37½	240
12:51	225		34	210	220	37½	240
13:18	225		35	200	225	38	235
13:41	240		35½	230	205	38	245
14:08	220		33	220	215	37½	245
14:39	225		35	210	215	37½	245
15:08	230		33	210	215	37½	245
15:37	225		34	210	215	37½	240

Date: 82-11-18

Incinerator operating conditions

Test No 4

Furnace No 3

time	Steam pressure (lbs/in ²)	Steam temperature (° F)	Steam flow rate (lbs/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 % damper opening	Air flow rate zone 4 % damper opening	Air flow rate zone 5 % damper opening	Total air flow rate (ft ³ /min.)	Furnace temperature (°F)
10:00	230	480	76 000	650 232	11	48	48	20	25 000	1 320
10:31	230	480	76 000	650 263	14	45	46	18	25 000	1 300
11:00	240	475	93 000	650 294	10	36	35	20	22 000	1 320
11:30	230	480	75 000	650 325	12	39	45	20	24 000	1 280
12:00	230	485	67 000	650 357	14	56	51	21	28 000	1 280
12:31	245	490	93 000	650 391	10	47	51	21	26 000	1 340
13:01	240	485	74 000	650 422	11	65	51	21	27 000	1 260
13:30	230	480	68 000	650 454	--	50	50	21	27 000	1 340
14:05	235	480	82 000	650 492	--	45	44	21	25 000	1 320
14:33	240	480	84 000	650 521	--	40	53	21	26 000	1 300
15:00	230	485	75 000	650 550	--	34	45	21	24 000	1 300

Date: 82-11-19

* Multiply by 1 200 lbs/hr

Incinerator operating conditions

Test No 4

Furnace No 4

time	Steam pressure (lbs/in ²)	Steam temperature (° F)	Steam flow rate (lbs/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 % damper opening	Air flow rate zone 4 % damper opening	Air flow rate zone 5 % damper opening	Total air flow rate (ft ³ /min.)	Furnace temperature (°F)
10:02	235	495	77 000	503 808	10	50	70	49	24 000	1 330
10:32	235	490	88 000	503 840	9	60	70	50	25 000	1 340
11:02	235	490	87 000	503 875	10	52	65	48	23 000	1 390
11:32	230	490	84 000	503 905	8	60	80	50	26 000	1 340
12:01	230	490	84 000	503 938	10	40	71	40	22 000	1 380
12:33	240	500	74 000	503 974	10	57	66	50	24 000	1 370
13:02	240	495	78 000	504 004	10	55	66	50	24 000	1 330
13:31	230	495	72 000	504 035	10	60	55	50	23 000	1 360
14:06	235	495	78 000	504 072	10	47	60	50	23 000	1 340
14:34	245	495	91 000	504 102	9	45	73	50	23 000	1 320
15:01	230	495	72 000	504 131	10	39	70	51	23 000	1 320

Date: 82-11-19

* Multiply byr 1 200 lbs/hr

Characteristics of electrofilters

Test No 4

Furnace No 3

	Input field		Secondary		Output field		Secondary	
	Primary		MA. D.C.		Primary		MA. D.C.	
	Volt A.C.	AMP. A.C.			VOLT A.C.	AMP. A.C.		
10:10	210	31	180		210	36	210	
10:37	200	30	180		210	36	225	
11:07	210	30	210		215	36	225	
11:40	210	30	190		210	35	225	
12:08	200	30	170		205	36	225	
12:41	210	30	190		205	36	225	
13:12	200	31	210		210	36	225	
13:42	210	30	180		215	36	225	
14:10	210	31	170		210	36	230	
14:40	210	29	190		210	34	215	
15:08	210	31	200		210	36	225	

Date: 82-11-19

Characteristics of electrofilters

Test No 4

Furnace No 4

	Input field		Secondary		Output field		Secondary	
	Primary		Primary		Primary		Primary	
	Volt A.C.	AMP. A.C.	MA. D.C.		VOLT A.C.		MA. D.C.	
10:11	210	32	180		225	37	230	
10:38	240	35	210		220	37½	240	
11:08	220	32	200		215	37½	230	
11:41	210	32	200		215	37½	235	
12:09	240	35	210		210	37½	240	
12:42	220	34	210		225	37½	235	
13:12	240	34	220		215	37½	245	
13:43	220	34	200		215	37½	230	
14:11	220	32	195		215	37½	235	
14:40	230	36	225		205	37½	240	
15:09	230	34	210		215	37½	240	

Date: 82-11-19

APPENDIX 2

INCINERATOR OPERATING CONDITIONS

MARCH 1983 SAMPLING



Incinerator operating conditions

Test No 1

Furnace No 1

Time	Steam pressure (lbs/in ²)	Steam temperature (° F)	Steam flow rate (lbs/hr)	Steam flow rate integrator*	Oxygen analyzer (% O ₂)	Air flow rate zone 3 (ft ³ /min)	Air flow rate zone 4 (ft ³ /min)	Air flow rate zone 5 (ft ³ /min)	Total air flow rate (ft ³ /min)	Furnace temperature (° F)
9:10	235	540	80 000	266 519	7,2	11 000	8 500	6 500	21 000	1 380
9:27	235	538	64 000	266 538	9	11 900	8 900	7 100	22 000	1 390
9:45	240	540	82 000	266 559	7	11 000	8 700	6 500	22 000	1 420
10:00	240	540	74 000	266 574	8,2	12 000	9 200	6 000	21 000	1 440
10:15	237	535	78 000	266 594	9	11 800	9 300	6 000	21 000	1 430
10:30	240	540	82 000	266 609	8,2	11 800	9 700	6 000	21 500	1 390
10:45	245	542	90 000	266 627	7,8	10 000	9 800	6 100	21 000	1 460
11:00	242	540	76 000	266 646	7	11 600	9 200	7 000	--	1 440
11:15	240	538	80 000	266 660	9,5	11 200	9 200	7 000	--	1 450
11:30	240	540	76 000	266 676	7,2	11 000	9 300	7 000	--	1 420
11:45	240	540	76 000	266 695	10	12 250	10 500	6 500	--	1 380
12:00	240	540	80 000	266 709	8,5	9 700	9 200	7 200	--	1 400
12:15	237	538	76 000	266 725	7	11 000	9 500	7 000	--	1 380
12:30	235	530	72 000	266 744	10	9 300	9 300	6 300	--	1 420
12:45	240	540	80 000	266 757	9	9 500	9 100	6 300	--	1 400
12:55	240	535	76 000	266 771	9	8 400	8 800	7 800	--	1 440

Date: 83-03-15

* Multiply by 1 200 lbs/hr

Characteristics of electrofilters

Test No 1

Furnace No 1

	Field 1		Field 2		Field 3	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
	Volt A.C.	AMP. A.C.	VOLT A.C.	MA. D.C.	VOLT A.C.	MA. D.C.
9:20	290	72	280	400	310	130
9:35	310	82	280	450	320	128
9:50	320	82	280	440	320	128
10:05	325	80	280	430	320	128
10:20	320	83	280	445	320	128
10:35	325	82	280	435	310	128
10:55	320	82	280	420	320	128
11:10	330	82	290	410	310	128
11:20	330	70	280	400	320	125
11:35	310	72	280	400	320	127
11:52	330	84	280	450	320	128
12:10	310	80	280	410	320	130
12:20	310	85	280	450	310	130
12:40	310	85	280	450	320	130
12:50	310	85	280	450	320	130
13:00	320	85	280	450	320	128

Date: 83-03-15

Incinerator operating conditions

Test No 2

Furnace No 1

time	Steam pressure (lbe/in ²)	Steam temperature (° F)	Steam flow rate (lbe/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 (ft ³ /min)	Air flow rate zone 4 (ft ³ /min)	Air flow rate zone 5 (ft ³ /min)	Total air flow rate (ft ³ /min)	Furnace temperature (° F)
1:15	240	540	66 000	266 791	7,5	10 000	9 200	7 800	--	1 420
1:30	240	540	76 000	266 810	9	10 000	9 000	7 500	--	1 420
1:45	245	550	88 000	266 824	8,2	8 200	8 200	7 900	--	1 420
2:00	243	545	82 000	266 844	9	9 000	8 700	7 900	--	1 420
2:15	245	550	84 000	266 857	8,5	10 000	9 100	7 400	--	1 420
2:30	245	545	80 000	266 874	9,5	10 900	9 500	7 400	--	1 430
2:45	240	540	78 000	266 891	10,2	11 000	9 500	7 200	25 500	1 420
3:00	240	540	76 000	266 907	10,1	11 000	9 400	10 200	26 000	1 420
3:15	237	537	88 000	266 923	8,8	11 000	9 000	7 500	25 500	1 420
3:30	236	540	68 000	266 938	10,2	11 500	10 100	8 000	26 800	1 360
3:45	244	545	82 000	266 953	9	10 000	8 900	7 800	25 500	1 390
4:00	242	540	88 000	266 970	9	9 500	8 950	7 800	24 500	1 420
4:15	240	542	84 000	266 988	8,5	9 800	9 000	7 800	24 500	1 420
4:30	245	545	88 000	267 006	8	8 100	8 300	8 000	24 000	1 440

Date: 83-03-15

* Multiply by 1 200 lbe/hr

Characteristics of electrofilters

Test No 2

Furnace No 1

Field 1			Field 2			Field 3		
Primary	Secondary	Primary	Primary	Secondary	Primary	Primary	Secondary	Primary
Volt A.C.	AMP. A.C.	MA. D.C.	VOLT A.C.	AMP. A.C.	MA. D.C.	VOLT A.C.	AMP. A.C.	MA. D.C.
1:20	320	80	400	260	101	550	310	130
1:35	320	85	450	280	100	545	320	128
1:50	320	84	450	280	101	545	320	128
2:05	320	82	440	280	100	540	320	128
2:20	320	80	410	290	100	540	320	130
2:35	310	82	420	290	100	540	320	130
2:50	310	85	450	280	101	550	320	128
3:05	320	82	430	280	101	550	320	128
3:20	310	80	420	280	101	545	320	128
3:35	320	83	440	290	101	540	320	127
3:50	320	80	440	295	100	530	320	127
4:05	320	82	410	295	100	530	310	128
4:20	330	82	440	290	100	530	310	130
4:35	320	82	440	280	100	530	310	128

Date: 85-03-15

Incinerator operating conditions

Test No 3

Furnace No 1

time	Steam pressure (lbs/in ²)	Steam temperature (° F)	Steam flow rate (lbs/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 (ft ³ /min)	Air flow rate zone 4 (ft ³ /min)	Air flow rate zone 5 (ft ³ /min)	Total air flow rate (ft ³ /min)	Furnace temperature (° F)
8:10	235	530	76 000	269 765	10,5	9 000	9 000	8 000	27 000	1 410
8:31	235	530	65 000	269 785	11,8	8 900	9 000	8 000	26 000	1 410
8:50	250	540	72 000	269 802	10,2	7 900	9 000	8 000	27 000	1 410
9:15	242	540	80 000	269 828	9,8	9 700	9 700	6 500	25 500	1 420
9:30	242	542	72 000	269 845	9,5	12 250	10 300	6 000	26 500	1 440
9:45	237	537	65 000	269 863	12	12 250	10 900	6 000	27 000	1 380
10:00	235	540	70 000	269 874	11,5	12 250	11 100	6 000	27 000	1 360
10:15	237	540	78 000	269 888	9,5	9 500	10 000	6 500	26 000	1 340
10:30	240	540	83 000	269 904	8,3	8 900	9 300	6 700	25 000	1 420
10:45	240	540	78 000	269 922	8,2	7 500	8 900	6 700	24 000	1 460
11:00	240	540	84 000	269 937	8,5	7 800	8 700	6 300	24 000	1 450
11:15	243	540	81 000	269 953	8,3	8 300	8 800	6 700	24 000	1 450

Date: 83-03-17

* Multiply by 1 200 lbs/hr

Furnace No 1

Date: 83-03-17

Incinerator operating conditions

Test No 4

Furnace No 1

time	Steam pressure (lbe/in ²)	Steam temperature (° F)	Steam flow rate (lbe/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 (ft ³ /min)	Air flow rate zone 4 (ft ³ /min)	Air flow rate zone 5 (ft ³ /min)	Total air flow rate (ft ³ /min)	Furnace temperature (° F)	Opacity (%)
11:45	250	550	90 000	269 988	8,1	8 300	8 300	6 900	23 000	1 490	8,0
12:00	245	545	82 000	270 005	8,1	8 600	8 700	6 700	23 000	1 450	7,0
12:15	245	550	84 000	270 022	8,0	8 000	8 200	6 800	23 000	1 460	7,0
12:30	247	550	86 000	270 042	7,2	7 500	7 900	6 700	23 000	1 480	8,0
12:45	245	548	80 000	270 057	8,0	7 700	8 000	6 700	22 000	1 480	8,0
13:00	245	544	82 000	270 074	7,6	7 000	8 100	6 700	22 500	1 470	8,0
13:16	245	545	76 000	270 092	7,7	6 500	7 800	6 700	22 500	1 500	8,0
13:30	237	540	72 000	270 107	8,0	6 500	8 000	6 700	22 500	1 500	8,0
13:45	245	540	82 000	270 124	7,0	6 600	8 000	6 800	22 500	1 500	8,0
14:00	245	545	82 000	270 140	6,0	6 600	8 000	6 200	22 000	1 500	8,0
14:15	245	540	92 000	270 158	6,3	6 300	7 700	6 800	20 000	1 500	8,5
14:30	240	540	80 000	270 175	6,0	6 300	7 900	6 800	20 000	1 510	9,0
14:45	245	540	84 000	270 196	7,0	6 200	7 800	6 800	20 500	1 500	8,0
15:00	245	540	88 000	270 211	6,2	6 300	8 100	6 800	21 500	1 540	8,0
15:15	245	542	88 000	220 230	6,0	6 600	8 000	6 800	22 000	1 520	8,0
15:30	242	540	86 000	270 247	8,5	5 400	7 900	6 800	22 000	1 520	8,0

Date: 83-03-17

* Multiply by 1 200 lbe/hr

Characteristics of electrofilters

Test No 4

Furnace No 1

	Field 1		Field 2		Field 3		
	Primary Volt A.C.	AMP. A.C.	Secondary MA. D.C.	Primary VOLT A.C.	Secondary MA. D.C.	Primary VOLT A.C.	
11:51	315	87	460	280	103	300	730
12:05	330	85	450	280	103	310	730
12:20	330	87	430	280	103	320	710
12:35	330	87	450	280	103	320	700
12:50	325	83	445	290	101	320	700
13:05	325	82	430	280	101	320	700
13:21	330	80	400	280	101	320	680
13:34	340	82	425	300	100	315	700
13:49	325	84	420	290	101	315	700
14:06	325	84	440	290	101	325	690
14:20	330	83	430	290	102	325	690
14:34	325	83	435	290	101	325	680
14:52	330	82	440	290	101	325	690
15:05	320	82	420	290	101	320	700
15:20	320	82	450	295	101	320	700
15:34	330	85	425	290	101	315	700

Date: 83-03-17

Incinerator operating conditions

Test No 5

Furnace No 1

time	Steam pressure (lbs/in ²)	Steam temperature (° F)	Steam flow rate (lbs/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 (ft ³ /min)	Air flow rate zone 4 (ft ³ /min)	Air flow rate zone 5 (ft ³ /min)	Total air flow rate (ft ³ /min)	Furnace temperature (°F)	Opacity (%)
8:30	245	545	86 000	289 035	6,8	11 000	9 100	8 000	25 000	1 470	7,0
8:45	242	540	90 000	289 052	8,0	8 500	8 500	8 200	24 000	1 540	7,0
9:02	243	540	86 000	289 074	7,8	8 200	8 300	8 200	24 000	1 500	6,0
9:15	242	540	84 000	289 088	9,2	9 000	8 900	8 100	24 000	1 480	6,0
9:30	243	543	84 000	289 104	7,0	9 400	9 000	8 000	24 000	1 440	6,0
9:45	242	540	80 000	289 122	8,1	9 400	9 000	8 000	24 000	1 440	6,0
10:00	243	540	96 000	289 140	7,2	8 800	8 600	8 100	24 000	1 490	6,0
10:15	240	540	77 000	289 157	8,5	9 200	8 800	8 000	24 000	1 490	6,5
10:31	233	541	79 000	289 175	10,4	9 200	8 800	8 000	24 000	1 440	6,2
10:45	225	542	78 000	289 189	9,7	9 400	9 200	8 000	24 000	1 400	6,0
11:00	240	540	76 000	289 204	8,7	9 800	9 000	8 000	24 000	1 410	6,2
11:15	240	542	84 000	289 221	8,5	9 700	9 000	8 000	24 000	1 450	6,4
11:30	245	535	82 000	289 240	9,5	9 800	8 700	8 100	24 500	1 490	7,0
11:45	237	538	70 000	289 256	9,5	9 800	9 200	8 000	24 000	1 440	7,0
12:00	240	538	76 000	289 271	9,8	9 300	9 200	8 000	24 000	1 400	7,0
12:15	238	542	75 000	289 286	10,0	9 600	9 100	8 000	24 000	1 380	7,0
12:30	240	540	80 000	289 304	7,8	9 200	8 500	8 000	24 000	1 400	7,5
12:45	240	540	80 000	289 319	8,9	8 000	8 700	8 100	24 000	1 420	7,5
13:00	240	535	80 000	289 334	7,8	9 200	8 400	8 000	24 000	1 420	7,0

Date: 83-03-29

* Multiply by 1 200 lbs/hr

Characteristics of electrofilters

Table No 5

Furnace No 1

	Field 1			Field 2			Field 3		
	Primary	AMP. A.C.	MA. D.C.	Primary	AMP. A.C.	MA. D.C.	Primary	AMP. A.C.	MA. D.C.
	Volt A.C.			VOLT A.C.			VOLT A.C.		
8:40	310	80	440	290	102	550	310	130	710
8:51	325	83	450	285	103	550	310	128	700
9:08	325	85	445	285	102	550	325	128	700
9:21	320	82	440	290	101	550	320	128	700
9:35	330	83	440	300	100	540	315	128	700
9:52	325	82	440	300	100	530	315	128	700
10:05	330	82	435	290	100	540	310	130	720
10:19	320	82	440	290	101	540	325	126	690
10:38	310	75	380	300	100	540	325	127	690
10:49	320	75	430	300	100	530	325	126	685
11:04	325	82	440	290	101	540	325	128	700
11:19	325	80	440	300	100	535	320	128	700
11:35	310	85	450	300	100	540	320	129	700
11:50	325	80	450	300	100	540	320	130	700
12:06	325	82	440	300	100	530	320	127	700
12:19	330	83	450	295	101	550	325	128	700
12:35	325	80	420	290	101	550	325	127	700
12:50	325	80	420	300	100	540	325	127	690
13:05	325	83	430	295	100	540	320	127	690

Date: 83-03-29

Incinerators operating conditions

Test No 6

Furnace No 1

time	Steam pressure (lbs/in ²)	Steam temperature (° F)	Steam flow rate (lbs/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 (ft ³ /min)	Air flow rate zone 4 (ft ³ /min)	Air flow rate zone 5 (ft ³ /min)	Total air flow rate (ft ³ /min)	Furnace temperature (°F)	Opacity (%)
13:30	243	540	85 000	289 369	7,8	8 500	8 200	8 200	24 000	1 440	7,0
13:45	241	544	90 000	289 386	6,9	8 200	8 100	8 200	24 000	1 480	7,9
14:00	241	550	83 000	289 403	9,2	9 200	8 700	8 200	24 000	1 480	8,0
14:15	245	550	82 000	289 420	8,3	8 900	9 500	8 000	24 000	1 450	7,8
14:30	235	540	63 000	289 437	8,2	9 300	9 400	7 900	24 000	1 420	7,8
14:45	245	550	84 000	289 453	8,4	9 000	9 100	8 000	24 500	1 460	7,8
15:00	247	550	78 000	289 470	8,8	9 000	9 000	8 000	24 000	1 420	7,8
15:15	245	545	80 000	289 487	7,8	9 000	9 000	8 000	24 000	1 420	7,8
15:30	248	550	94 000	289 504	6,9	8 900	8 700	8 000	24 000	1 460	7,5
15:45	247	547	90 000	289 523	7,2	8 500	8 500	8 100	24 000	1 510	7,5
16:00	245	542	80 000	289 538	7,7	9 500	9 200	8 000	24 000	1 480	7,0
16:18	243	540	84 000	289 561	7,4	9 500	9 000	8 000	24 000	1 480	7,5
16:30	241	540	64 000	289 575	10,3	9 200	9 000	8 000	24 000	1 500	7,0
16:45	244	545	72 000	289 589	8,4	9 300	8 700	8 000	24 000	1 410	7,0
17:00	243	540	84 000	289 607	8,0	9 300	8 700	8 000	24 000	1 440	7,0
17:15	241	540	80 000	289 622	7,5	9 300	8 700	8 000	24 000	1 460	7,0
17:30	243	542	78 000	289 639	7,1	8 700	8 700	8 100	24 000	1 460	7,0

Date: 83-03-29

* Multiply by 1 200 lbs/hr

Characteristics of electrofilters

Test No 6

Furnace No 1

	Field 1		Field 2		Field 3	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
	Volt A.C.	AMP. A.C.	VOLT A.C.	MA. D.C.	VOLT A.C.	MA. D.C.
13:35	325	85	295	440	315	128
13:53	325	75	300	425	320	127
14:04	320	80	285	450	320	128
14:20	325	83	285	440	320	128
14:34	325	79	300	440	325	128
14:52	330	82	290	445	325	127
15:05	320	80	295	420	320	128
15:20	320	82	310	420	325	127
15:35	325	83	300	440	320	128
15:49	325	84	290	450	325	127
16:05	325	83	300	440	325	127
16:21	330	81	290	440	325	125
16:35	315	83	290	440	325	124
16:49	325	83	290	430	320	126
17:07	320	80	290	410	320	127
17:20	315	77	295	400	315	128
17:35	325	80	290	410	315	129

Date: 83-03-29

Incinerator operating conditions

Test No 7

Furnace No 1

time	Steam pressure (lbs/in ²)	Steam temperature (° F)	Steam flow rate (lbs/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 (ft ³ /min)	Air flow rate zone 4 (ft ³ /min)	Air flow rate zone 5 (ft ³ /min)	Total air flow rate (ft ³ /min)	Furnace temperature (° F)	Opacity (%)
9:00	245	548	88 000	290 685	10,0	12 000	10 900	6 700	26 000	1 460	6,0
9:15	241	540	83 000	290 703	7,7	10 900	10 900	6 700	26 000	1 440	6,1
9:30	244	541	96 000	290 721	7,3	11 000	11 100	6 700	26 000	1 430	6,0
9:45	245	540	92 000	290 739	8,2	10 300	10 800	6 900	26 000	1 460	6,1
10:00	247	545	88 000	290 759	8,4	9 600	9 300	7 200	26 000	1 510	6,1
10:18	242	540	80 000	290 779	8,0	9 500	10 200	7 000	26 000	1 460	7,0
10:30	240	530	81 000	290 793	8,7	10 200	9 500	7 000	25 500	1 480	7,0
10:45	238	532	72 000	290 811	9,3	10 000	10 500	7 000	25 000	1 440	6,5
11:00	245	540	92 000	290 828	7,5	8 300	10 300	7 200	25 000	1 460	7,0
11:15	240	535	84 000	290 846	9,4	10 100	10 000	7 000	25 000	1 460	7,0
11:33	237	530	84 000	290 866	10,0	10 000	10 600	7 000	25 500	1 480	7,5
11:45	242	540	82 000	290 881	9,7	10 100	10 700	6 900	25 500	1 500	7,5
12:00	240	530	80 000	290 896	9,7	10 100	10 700	6 900	25 500	1 480	7,8
12:15	240	535	70 000	290 914	9,1	11 100	11 100	6 700	26 500	1 460	7,8
12:33	240	530	80 000	290 931	9,7	11 300	11 100	6 700	26 500	1 450	7,8

Date: 83-03-30

* Multiply by 1 200 lbs/hr

Characteristics of electrofilters

Test No 7

Furnace No 1

	Field 1			Field 2			Field 3		
	Primary	Secondary		Primary	Secondary		Primary	Secondary	
	Volt A.C.	AMP. A.C.	MA. D.C.	VOLT A.C.	MA. D.C.	AMP. A.C.	VOLT A.C.	AMP A.C.	MA. D.C.
9:05	320	82	400	280	400	100	315	126	690
9:21	320	83	425	280	425	102	320	126	690
9:35	315	82	450	290	450	102	315	128	700
9:49	325	81	430	280	430	102	315	128	700
10:06	325	82	440	280	440	102	315	128	700
10:23	325	80	450	280	450	102	310	128	700
10:36	330	82	425	290	425	101	310	130	720
10:50	320	80	425	300	425	100	310	130	700
11:06	315	80	425	280	425	99	320	127	690
11:20	310	78	380	300	380	100	310	127	690
11:30	300	80	400	290	400	100	310	127	700
11:50	300	70	350	290	350	101	320	127	700
12:05	305	82	450	300	450	101	320	130	700
12:22	300	80	400	300	400	101	320	130	700
12:39	315	75	400	290	400	99	315	124	680

Date: 83-03-30

Incinerator operating conditions

Test No 8

Furnace No 1

time	Steam pressure (lbs/in ²)	Steam temperature (° F)	Steam flow rate (lbs/hr)	Steam flow rate integrator*	Oxygen analyser (% O ₂)	Air flow rate zone 3 (ft ³ /min)	Air flow rate zone 4 (ft ³ /min)	Air flow rate zone 5 (ft ³ /min)	Total air flow rate (ft ³ /min)	Furnace temperature (° F)	Opacity (%)
12:45	236	530	70 000	290 945	9,0	11 200	11 100	6 800	26 000	1 460	8,5
13:00	242	540	82 000	290 958	7,7	11 200	11 200	6 800	26 000	1 460	9,0
13:15	247	545	88 000	290 976	9,7	9 500	11 500	7 000	26 000	1 510	8,0
13:30	245	540	90 000	290 994	8,7	8 300	10 800	7 000	25 500	1 510	8,0
15:45	240	540	80 000	291 011	9,8	11 300	10 200	6 900	25 500	1 500	8,0
14:00	245	540	86 000	291 028	7,9	11 300	10 100	7 000	25 500	1 520	8,5
14:15	242	540	76 000	291 045	9,8	11 700	10 300	6 700	26 000	1 475	8,5
14:30	239	540	70 000	291 061	8,8	11 200	11 500	6 500	26 000	1 480	8,0
14:45	245	540	80 000	291 077	10,0	10 000	11 800	6 700	26 000	1 520	8,0
15:00	242	535	84 000	291 095	8,8	9 200	12 000	6 800	25 500	1 540	8,0
15:16	245	540	84 000	291 112	9,9	11 200	11 700	6 600	26 000	1 540	8,0
15:30	240	537	77 000	291 127	10,7	11 200	11 700	6 500	26 000	1 530	8,0
15:45	245	540	80 000	291 143	9,8	11 200	11 700	6 600	26 000	1 520	8,5
16:00	247	530	74 000	291 160	9,3	11 100	11 500	6 500	26 000	1 520	8,0

Date: 83-03-30

* Multiply by 1 200 lbs/hr

Furnace No 1

Date: 83-03-30

APPENDIX 3

SAMPLING AND RECOVERY PROCEDURES

1.0 Sampling method

EPS report 1-AP-74-1, "Standard Reference Methods for Source Testing: Measurement of Emissions of Particulates from Stationary Sources", was used as a basis for the sampling. The method was altered, however, to take account of requirements relating to the sampling of dioxins and furans.

1.1 Sampling train

The sampling train (see Figure 1) consisted in:

- (1) a stainless steel nozzle, 7.94 mm (0.3125 inch) in diameter.
- (2) a 3-metre long stainless steel probe, equipped with an S-type pitot tube to measure gas velocity, a thermocouple to measure gas temperature, a heating element to maintain the probe temperature at the stack gas temperature, or at a minimum of 120° C (250°F), and a thermocouple to measure the probe temperature.
- (3) a filter holder and a filter support. The filter holder was made of glass, and the filter support of stainless steel. (Fritted glass or stainless steel could not be used because of the difficulty of decontaminating them.) The gasket for the filter support was of Vitron A, a fluoride hydrocarbon similar to Teflon. (Gaskets for the filter holders or filter supports could be of rubber or silicone, but great care is required when removing used filters so as not to detach rubber or silicone particles.) The filter was placed in a heated box where the temperature was maintained at a minimum of 120° C (250° F). Fibreglass filters must

be of "Spectrograde" quality, and should not be marked with any identification or number. The use of a cyclone between the probe and the filter is not necessary.

- (4) a resin adsorption and condensation system, including a cooling and adsorption unit, a condensation water tank and an adsorption unit.

The gas is cooled as it passes through a coil in the upper part of the cooling and adsorption unit; the lower section of the unit contains the XAD-2 resin. The entire unit is cooled by circulating ice water from the tank containing the impingers. The flow of water, controlled by a submersible pump, must be variable, so that the gas temperature when it leaves the unit will be between 0° C and 25° C, to ensure that the resin does not decompose. The water flow must be at least 300 to 400 ml/minute.

The Y-tube connects the cooling and adsorption unit and the adsorption unit to the condensation water tank. The tube is equipped with a thermocouple well, where the gas temperature is measured. (In commercial sampling trains, a thermocouple connection is normally available to measure the gas temperature as it leaves the last impinger. For the sampling of dioxins and furans, it is not necessary to measure the temperature at that point; so the connection for that purpose is used to measure the temperature in the Y-tube). The adsorption unit is completely filled with XAD-2 resin.

The units containing the resin must at all times be covered with aluminum foil. The tube connecting the filter holder to the cooling and adsorption unit must also be covered with aluminum foil.

The entire system is too large to be placed in the ice bath tank holding the impingers. Instead, it was placed in a box attached to the outside of the tank, but which extended no farther than the bottom of the tank.

If the sampling was to be done during cold weather, the box had to be insulated, if necessary. No ice could be allowed to form in the Y-tube, as it would plug the drain and let condensation water accumulate in the adsorption unit.

(5) Three impingers, placed in the ice bath:

- an impinger containing 200 ml of ethylene glycol
- an empty impinger
- an impinger containing silica gel.

If the sampling was to be done in cold weather, the impingers had to be protected from frost by insulating the tank. The use of ethylene glycol or any other organic antifreeze in the impinger tank was unacceptable. Teflon sleeves were used to ensure that the necks of the impingers were watertight.

(6) A console with a vacuum pump, pressure gauge, adjustable flow valves, and electric switches.

(7) A diaphragm-type flowmeter.

(8) A calibrated dry gas counter.

All the materials used in the sampling train, in preparing the train, or in recovering the samples were either of glass, stainless steel, Teflon or aluminum foil.

The silicone grease normally used to seal the sampling train must not be used when sampling dioxins and furans. It was replaced with high-quality Teflon ribbon.

1.2 Preparation of the sampling train

The sampling train had to be decontaminated prior to sampling. The nozzle, probe, filter support and all glassware (first and last sections of the filter holder, the impingers and connectors) were cleaned and rinsed with methanol, iso-octane* and methylene chloride. All the glassware was then placed in the oven for at least 12 hours, at a temperature of 150-175°C. The stainless steel filter support was placed in the oven for 12 hours at a temperature of about 70°C.

1.3 Recovery of samples

The sampling train was prepared and the samples recovered by the contractor in the Environment Canada Capitaine Bernier Laboratory in Longueuil.

The samples were recovered in the following way:

- first sample: nozzle, probe and front section of the filter holder.
 - . The nozzle, probe and front section of the filter holder were brushed and rinsed with methanol. The solvent was collected in an amber glass bottle.

* In the recovery preparation procedures, it is recommended from now on that hexane be used rather than iso-octane.

- . The parts were then rinsed with iso-octane and methylene chloride, and the solvents collected in the bottle used in the previous step.
- second sample: fibreglass filter
 - . The filter was carefully removed from the filter support.
 - . It was placed in a petri dish, which was then sealed and covered with aluminum foil. It was not dried or weighed.
- third sample: blank. Nozzle, probe and the front section of the filter holder.
 - . The nozzle, the probe and the front section of the filter holder were rinsed with methanol, and then with iso-octane, and finally with methylene chloride. All the solvents were collected in an amber glass bottle.
- fourth sample: cooling and adsorption unit
 - . The cooling and adsorption unit containing the resin was weighed and then sealed with glass plugs.
 - . The unit must be properly covered with aluminum foil.
- fifth sample: adsorption unit
 - . The adsorption unit was weighed and then sealed with glass plugs.
 - . The unit must be properly covered with aluminum foil.
- sixth sample: condensation water tank, Y-tube, rear section of the filter holder, and the tube connecting the filter holder and the cooling and adsorption unit.

- . After the condensation water tank was weighed, it was emptied into an amber glass bottle.
- . The tank, the Y-tube, the rear section of the filter holder and the tube connecting the filter holder and the cooling and adsorption unit were rinsed with distilled water, and then with iso-octane. The liquids were collected in the same amber glass bottle.
- seventh sample: the tube connecting the adsorption unit to the first impinger, the first impinger, the U-tube connecting the first and second impingers, the second impinger, and the U-tube connecting the second and third impingers.
 - . The three impingers were weighed.
 - . The contents of the first two impingers were emptied into an amber glass bottle.
 - . The first two impingers and connectors were rinsed with distilled water, and the water added to the same amber glass bottle.
- eighth sample: blank. All the glassware from the rear section of the filter holder on, including the filter support.
 - . All the glassware was rinsed with methanol, and then with iso-octane, and finally with methylene chloride. The solvents were collected in an amber glass bottle.

Note: (1) Acetone should not be used during the recovery of the samples.

(2) The solvents should be used in the prescribed order.

(3) The solvents in the sample should be listed on the sample identification label.

APPENDIX 4

DESCRIPTION OF SAMPLES ANALYSED



Appendix 4

Description of samples analysed November 1982

Test 1

Sample No	Description
51	Wash - nozzle, probe and front section of the filter holder Filter Rinse - nozzle, probe and front section of the filter holder
52	Condensation and adsorption unit (resin) Adsorption unit (resin) Contents and rinsing of condensation water tank and connector
53	Contents and rinsing of first two impingers and connectors Rinsing of glassware in rear section of train
17	Fly ash (left hopper of precipitator - unit 4)
18	Fly ash (right hopper of precipitator - unit 4)

Appendix 4 (cont'd)

Description of samples analysed
November 1982

Test 2

Sample No	Description
54	Wash - nozzle, probe and front section of the filter holder Filter Rinse - nozzle, probe and front section of the filter holder
55	Condensation and adsorption unit (resin) Adsorption unit (resin) Contents and rinsing of condensation water tank and connector
56	Contents and rinsing of first two impingers and connectors Rinsing of glassware in rear section of train
27	Fly ash (right hopper of precipitator - unit 4)
28	Fly ash (left hopper of precipitator - unit 4)

Appendix 4 (cont'd)

Description of samples analysed
November 1982

Test 3

Sample No	Description
31	Wash - nozzle, probe and front section of the filter holder
30	Filter
32	Rinse - nozzle, probe and front section of the filter holder
33	Condensation and adsorption unit (resin)
34	Adsorption unit (resin)
35	Contents and rinsing of condensation water tank and connector
36	Contents and rinsing of first two impingers and connectors
37	Rinsing of glassware in rear section of train
38	Fly ash (right hopper of precipitator - unit 4)
39	Fly ash (left hopper of precipitator - unit 4)

Appendix 4 (cont'd)

Description of samples analysed
November 1982

Test 4

Sample No	Description
40	Wash - nozzle, probe and front section of the filter holder
41	Filter
42	Rinse - nozzle, probe and front section of the filter holder
43	Condensation and adsorption unit (resin)
44	Adsorption unit (resin)
45	Contents and rinsing of condensation water tank and connector
46	Contents and rinsing of first two impingers and connectors
47	Rinsing of glassware in rear section of train
48	Fly ash (right hopper of precipitator - unit 4)
49	Fly ash (left hopper of precipitator - unit 4)
50	Solvent blank - acetone, methanol methylene chloride and iso-octane

Appendix 4 (cont'd)

Description of samples analysed
March 1983

Test 1

Sample No	Description
9 + 10 + 11	Wash - nozzle, probe and front section of the filter holder Filter Rinse - nozzle, probe and front section of the filter holder
12	Condensation and adsorption unit (resin)
13	Adsorption unit (resin)
14	Contents and rinsing of condensation water tank and connectors
15	Contents and rinsing of first two impingers and connectors
16	Rinsing of glassware in rear section of train

Appendix 4 (cont'd)

Description of samples analysed
March 1983

Test 2

Sample No	Description
17 + 18 + 19	Wash - nozzle, probe and front section of the filter holder Filter Rinse - nozzle, probe and front section of the filter holder
20 + 21 + 22	Condensation and adsorption unit (resin) Adsorption unit (resin) Contents and rinsing of condensation water tank and connectors
23 + 24	Contents and rinsing of first two impingers and connectors Rinsing of glassware in rear section of train

Appendix 4 (cont'd)

Description of samples analysed
March 1983

Test 3

Sample No	Description
25	Wash - nozzle, probe and front section of the filter holder
26	Filter
27	Rinse - nozzle, probe and front section of the filter holder
28	Condensation and adsorption unit (resin)
29	Adsorption unit (resin)
30	Contents and rinsing of condensation water tank and connectors
31	Contents and rinsing of first two impingers and connectors
32	Rinsing of glassware in rear section of train

Appendix 4 (cont'd)

Description of samples analysed
March 1983

Test 4

Sample No	Description
33 + 34 + 35	Wash - nozzle, probe and front section of the filter holder Filter Rinse - nozzle, probe and front section of the filter holder
36 + 37 + 38	Condensation and adsorption unit (resin) Adsorption unit (resin) Contents and rinsing of condensation water tank and connectors
39 + 40	Contents and rinsing of first two impingers and connectors Rinsing of glassware in rear section of train

Appendix 4 (cont'd)

Description of samples analysed
March 1983

Test 5

Sample No	Description
41 + 43	Wash - nozzle, probe and front section of the filter holder Rinse - nozzle, probe and front section of the filter holder
42	Filter
44	Condensation and adsorption unit (resin)
45	Adsorption unit (resin)
46	Contents and rinsing of condensation water tank and connectors
47	Contents and rinsing of first two impingers and connectors
48	Rinsing of glassware in rear section of train
73	Solid materials recovered during loading into a truck for landfill

Appendix 4 (cont'd)

Description of samples analysed
March 1983

Test 6

Sample No	Description
49 + 50 + 51	Wash - nozzle, probe and front section of the filter holder Filter Rinse - nozzle, probe and front section of the filter holder
52 + 53 + 54	Condensation and adsorption unit (resin) Adsorption unit (resin) Contents and rinsing of condensation water tank and connectors
55 + 56	Contents and rinsing of first two impingers and connectors Rinsing of glassware in rear section of train
74	Ash and residues collected under the residue evacuation hoppers of furnace No 1

Appendix 4 (cont'd)

Description of samples analysed March 1983

Test 7

Sample No	Description
57	Wash - nozzle, probe and front section of the filter holder
58	Filter
59	Rinse - nozzle, probe and front section of the filter holder
60	Condensation and adsorption unit (resin)
61	Adsorption unit (resin)
62	Contents and rinsing of condensation water tank and connectors
63	Contents and rinsing of first two impingers and connectors
64	Rinsing of glassware in rear section of train
75	Ash recovered from east hopper of the multicyclone of furnace No 1

Appendix 4 (cont'd)

Description of samples analysed
March 1983

Test 8

Sample No	Description
65 + 66 + 67	Wash - nozzle, probe and front section of the filter holder Filter Rinse - nozzle, probe and front section of the filter holder
68 + 69 + 70	Condensation and adsorption unit (resin) Adsorption unit (resin) Contents and rinsing of condensation water tank and connectors
71 + 72	Contents and rinsing of first two impingers and connectors Rinsing of glassware in rear section of train
76	Solid materials floating in the sedimentation tank of the incinerator

APPENDIX 5

ANALYTICAL METHOD

DRAFT

**SAMPLE PREPARATION FOR THE ANALYSIS AND
DETERMINATION OF POLYCHLORINATED DIBENZO-P-DIOXINS (PCDD) AND
POLYCHLORINATED DIBENZOFURANS (PCDF) IN EMISSION SAMPLES**

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March 1984



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1 SCOPE AND APPLICATION

This method is applicable to the determination of polychlorinated dibenzo-p-dioxin and polychlorinated dibenzo furans (PCDD/PCDF) in stack emission samples from municipal incinerators. These samples consist of particulate matters collected on glass-fibre filters, flyash, bottom ash, and adsorbent (XAD-2); liquid samples such as impinger catch solutions (ethylene glycol) and various washings of train components (water, hexane etc).

With suitable modification to the extraction and clean-up procedure depending on the sample matrices, this method has been successfully applied to a variety of environmental samples such as sediments, industrial wastes, sludges etc.

The minimum detectable amount for glass capillary gas chromatograph/low resolution mass spectrometer (GC2/LRMS; Finnigan 4500) is 5 pg PCDD/PCDF. For a final sample volume of 100 μ l and a 1- μ l injection, the minimum detectable amount of PCDD/PCDF in each sample is 0.5 ng per isomer.

2 SUMMARY OF METHOD

PCDD/PCDF adsorbed on particulate matter are soxhlet-extracted with toluene for a period of 16 to 24 hrs. Liquid samples are extracted with methylene chloride in separator funnels. Bulk matrix (toluene extractables other than PCDD/PCDF) are removed by passing the raw extract through a column of chemically modified adsorbent. The extracts are further purified by passage through a dual column system to remove common chemical interferences.

The purified sample residue is screened on a gas chromatograph equipped with glass capillary column and electron-capture detector. Qualitative identification is performed on a capillary column - equipped gas chromatograph/quadrupole mass spectrometer/data system (GC/MS/DS) using the retention times and relative abundance of 2-3 characteristic ions. Quantitation is performed using external and internal standards with the characteristic ions and estimated recovery factors.

3 INTERFERENCES

3.1 Interference may be caused by contaminants in solvents, reagents, glassware and other sample processing hardware that lead to discrete artifacts and/or elevated baselines in the analytical step. All these materials must be routinely demonstrated to be free from interferences under the conditions of the analysis by running procedure blanks.

3.2 All glassware must be scrupulously cleaned as soon as possible after use by rinsing with the last solvent used. This step is followed by detergent washing with hot water and rinses with tap water and deionised water. Drain and rinse 3 times each serially with acetone, hexane and methylene chloride. Allow the solvent rinsings to air-dry. Heat-treat in an oven set at 320°C overnight.

3.3 Matrix interferences are caused by contaminants that are co-extracted from the sample. The extent of such interferences will depend on the nature and complexity of the emission source under investigation. The adsorbent column chromatography used in the clean up procedure is designed to prevent GC, GC/MS interferences during the identification and quantitation phase of the method. The bulk of the matrix (toluene, hexane or methylene chloride extractables other than PCDD/PCDF) are removed by passage through a column of sulphuric acid and sodium hydroxide on silica. Sulphurous compounds are removed through the reaction with silver nitrate on silica in the top column of the tandem two-column system. Finally, common chemical interferences such as PCB, chlorinated-biphenyl ethers, chlorinated benzenes etc. are separated from PCDD/PCDF on the basic alumina column by eluting with hexane and 2% methylene chloride in hexane.

3.4 The elution pattern of PCDD/PCDF in the basic alumina column depends critically on the activity of alumina. It is recommended that both fractions (2% and 50% methylene chloride in hexane) be collected to make sure no PCDD/PCDF are lost through pre-mature elution in the 2% fraction. A standard mixture processed in the same manner can also be employed to monitor any sample loss.

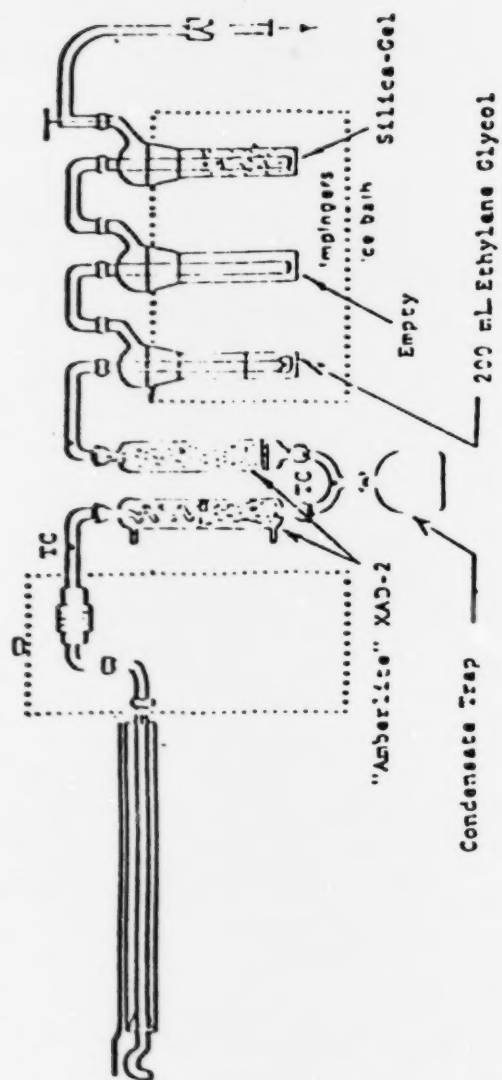
4 SAFETY AND PRECAUTION

In view of the toxic properties of PCDD/PCDF, rigorous safety and precaution procedures should be adopted to minimize exposure of laboratory personnel. Protective clothing overshoes and goggles should be worn at all times and working in a well-ventilated area is mandatory. Laboratory waste should be disposed of either by high-temperature incineration ($>1000^{\circ}\text{C}$) or by burial in an approved chemical landfill.

5 SAMPLING PROCEDURE AND STORAGE

5.1 Samples are collected using an organic sampling train similar to the modified EPA method No. 5 train (see Fig. 1). After sampling, samples are partitioned and recovered according to the procedures outlined in Table 1.

5.2 All samples are stored at 2°C in the dark to eliminate degradation.



TC - Thermocouples (Before & After Adsorbers)

FIGURE 1 SCHEMATIC OF "AMBERLITE" SAMPLING TRAIN

TABLE I SAMPLING PARTITIONING AND RECOVERY PROCEDURES FOR ORGANIC SAMPLING TRAIN

	Sample No.	Item	Procedures
Front Half	1	Nozzle, Probe, F-H Holder	Wash and brush hexane, methanol and methylene chloride into an amber glass bottle.
Front Half	2	Train Filter	Place in glass petri-dish and wrap in aluminum foil. No desiccation or weighing.
Front Half	3	Nozzle, Probe, F-H Holder	Rinse with hexane, methanol and methylene chloride into an amber glass bottle.
Back Half	4	Condensor and Amberlite Adsorber Assembly	Seal w̄ glass caps and wrap in aluminum foil.
Back Half	5	Back-up Amberlite Adsorber	Seal w̄ glass caps and wrap in aluminum foil.
Back Half	6	Condensate Trap and Connector	Empty contents and rinse with d H ₂ O and hexane into an amber glass bottle.
Back Half	7	1st and 2nd Impingers and Connectors	Empty contents and rinse with ethylene glycol and d H ₂ O into an amber glass bottle.
Back Half	8	B-H Glassware (Impingers, Connectors, Condensate Trap, B-H Holder)	Rinse w̄ hexane, methanol, methylene chloride into an amber glass bottle.

6 REAGENTS

6.1 Chemicals and Solvents

All lab chemicals, including H_2SO_4 , AgNO_3 , NaOH are ACS reagent grade. All solvents used are pesticide grade.

6.2 Dioxin and Furan Standards

All native and labelled standards are obtained from KOR Ltd., USA. Solids are weighed on an analytical balance (capable of accurately weighing 0.00001 g) and dissolved in toluene. Serial dilutions are made from the stock solution.

Furan standards were obtained from Dr. D. Stalling of U.S. Fisheries Service and Dr. S. Safe of the Texas A and M. University.

6.3 Adsorbent Preparation

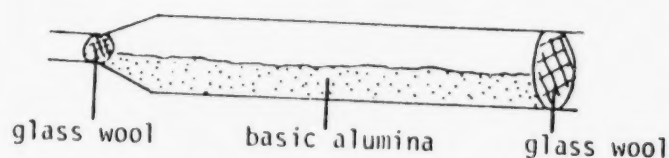
6.3.1 Silica. Approximately 300 g of chromatographic grade silica acid (100 - 200 mesh, Bio-Sil A; Bio-Rad Lab.) is dried in the oven for approx. 30 min at 180°C . Remove from oven and allow to cool. Fill a suitable column to half-full, rinse consecutively with approx. 250 ml methanol and 250 ml methylene chloride. Allow the solvent to drain. After drying the washed silica at 50°C for 1/2 hr. in an oven, the temperature is increased in a step-wise manner to 180°C for 2 hrs.

6.3.2 44% H_2SO_4 on Silica. Add 78.6 g. conc. H_2SO_4 in a stepwise fashion (5 ml at a time) directly to 100 g silica prepared as described above in a 500 ml erlenmeyer flask. This yields an acid concentration of 44% based upon total weight. Shake the material manually until no clumps can be observed. Stopper and store in a desiccator until use. (Caution: This material has all the property of conc. H_2SO_4 , handle with care.)

6.3.3 33% 1 M NaOH on Silica. For 50. silica, use 24.6. of 1 M NaOH solution. Proceed in the same manner as described above. To prepare 1 M NaOH , dissolve 5 g NaOH in 125 ml H_2O .

6.3.4 10% AgNO_3 on Silica. Dissolve 5.6 AgNO_3 in 21.5 g H_2O . The solution is added in a stepwise fashion to 50 g activated silica in an erlenmeyer flask with shaking to produce a uniformly coated, free-flowing powder. Allow to stand for approx. 1/2 hr. Replace the stopper loosely and put the flask in an oven at 70°C . In a stepwise manner over a period of 5 hr., raise the temp. to 120°C . The adsorbent is activated for an additional period of approx. 15 hr. at 125°C . Store in an amber glass bottle in a desiccator. Minimize exposure to light.

6.3.5 Basic Alumina. Prepare the alumina the day before use by transferring up to 20 g of basic alumina (AG 10, 100-200 mesh, Bio-Rad Lab) into a column (see diagram below) wash the alumina with 2-3 column volumes of methylene chloride followed by hexane. After draining, remove the rest of solvent from the column by vacuum. Lay the column in a horizontal position and tap the column until the alumina is evenly distributed as shown in the diagram below. Place the column in an oven at 60°C for 1 hr. then increase the oven temperature to 335°C covernight. Store the alumina at 110°C until use.



6.3.6 Sodium Sulphate. Reagent grade granular Na_2SO_4 is poured into a large column and washed with 2 equal volumes of hexane followed by methylene chloride. Dry sodium sulphate in oven at 50°C for 1 hr. then at 250°C for a few hours.

6.3.7 Glass Wool. Glass wool is placed in a large column and washed with 2 equal volumes of hexane and ethylene chloride. Allow to air dry and then heat treat overnight at 300°C.

7 APPARATUS

7.1 Glassware and Laboratory Supplies

7.1.1 Soxhlet extraction apparatus consists of water-cooled condenser, a 45 x 125 mm glass or cellulose thimble, 1000 ml boiling flask and a variac-controlled heating mantle.

7.1.2 Separatory Funnels.

7.1.3 Beakers, Erlenmeyer Flasks, Buchner Funnels, Stirrers, Forceps, Petric Dishes, Scalpel.

7.1.4 Expendables: Disposable Pipettes, Glass wool.

7.1.5 Rotary-evaporator (Buchii, Rotavapor R-110).

7.1.6 Chromatographic Columns: Acid/Base, Silver nitrate, Alumina (see Fig. 2).

7.1.7 Analytical Balance.

7.1.8 Reacti-vials, Amber Glass, 0.5 ml Capacity with Teflon-lined Screw Cap.

7.1.9 Appendorf Automatic Pipettes.

7.2 Gas Chromatographic Equipment

7.2.1 Hewlett-Packard (HP 5830A) or equivalent, equipped with Ni-63 electron capture detector and electronic integrator.

7.2.2 Column: DB-5, 60 m x 0.25 mm (polymethyl (5% phenyl) siloxane) durabond fused silica column, 0.25 μ m coating thickness.

7.2.3 Conditions: Injector temp, 280°C; detector temp, 300°C; carrier, He at linear velocity of 40 cm sec⁻¹; temp. program, 70°C/3 min - 20°C min⁻¹ - 210°C - 3°C min⁻¹ - 300°C/15 min. make-up gas, CH₄/Ar at 50 cc min⁻¹.

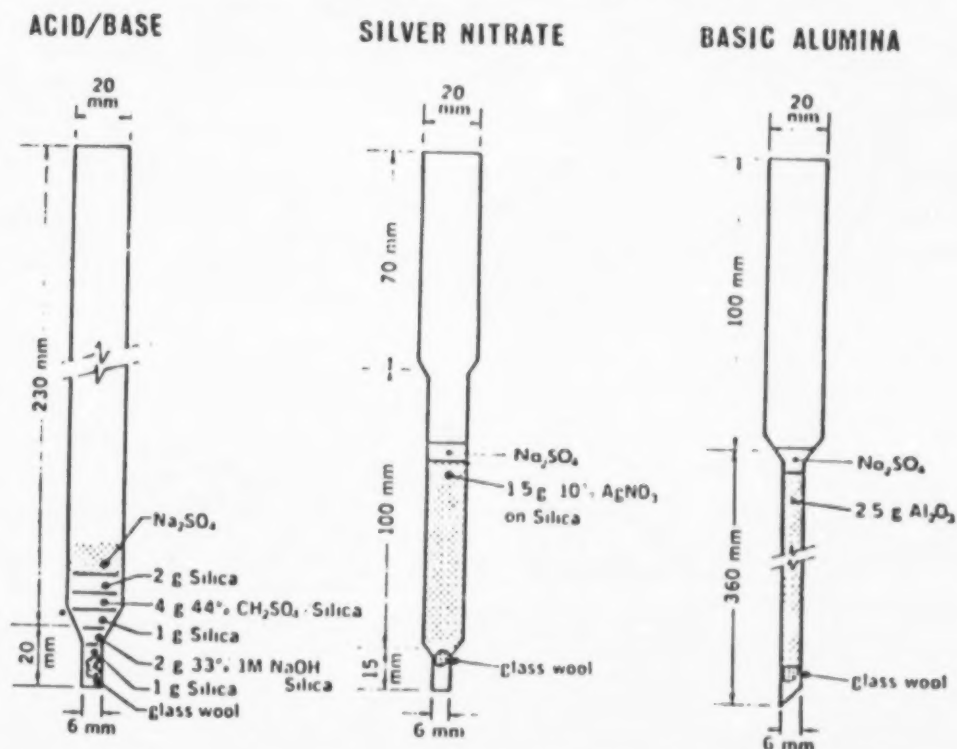
7.2.4 Injection mode: 1 μ l Auto injection, Grob splitless mode, purge stopped for 1.5 min, alternate wash cycle between samples.

7.3 GC/MS/DS Equipment

7.3.1 Finnigan 4500 - series quadrupole GC/MS with Incos data system or equivalent operating in multiple ion detection (MID) mode at unit resolution.

7.3.2 Column. Same as in 7.2.2

FIGURE 2 CHROMATOGRAPHIC COLUMNS FOR CLEAN-UP



7.3.3 GC Conditions. Temp program: $120^\circ\text{C}/1 \text{ min} - 15^\circ\text{C min}^{-1} - 200^\circ\text{C} - 2.5^\circ\text{C min}^{-1} - 280^\circ\text{C}/30 \text{ min}$. Capillary column fed directly into ion source. Interface temp: 285°C . $1 \mu\text{l}$ On-column injection. Carrier gas: He at linear velocity 40 cm sec^{-1} .

7.3.4 MS Conditions. Ion source temp: 150°C . Electron energy: 40 eV (nominal). Filament current: 0.3 mA. Scan range: 150 to 550 AMU in 1.1 sec. Ionisation mode: EI and negative methane CI. Ion detection: MID descriptors containing a 200 ms dwell/ion for each of 2-3 ions per isomer.

8 PROCEDURE

8.1 Sample Preparation

8.1.1 Solid Samples.

a) Flyash

- Pre-extract the soxhlet system by approx. 500 ml. Toluene at a cycle rate of 5-8 cycles 1 hr for 16-24 hr. Discard the toluene at the end of extraction.
- Weigh accurately 5-50 gm sample into a 400 ml beaker. Add 100 ml 1 M HCl, stir occasionally for approx. 1 hr. Filter through a glass-fibre filter in a Buchner funnel. Wash solids with small volumes of deionized (DI) water and continue suction for 1/2 hr. Spread solids out in a petric dish and air dry overnight.
- The filtrate (dil. HCl plus washings of the sample) is extracted with 100 ml (or 1/10 x volume of filtrate), 50 ml x 2 portions of CH_2Cl_2 in a separatory funnel. Dry the organic layer (bottom) by passing through a bed of hexane-rinsed Na_2SO_4 , into a 500 ml flask. Add 1 ml isooctane and concentrate to approx. 1 ml in a rotary-evaporator under reduced pressure at $\sim 30^\circ\text{C}$.
- Load air-dried sample solids into the thimble and return to soxhlet extractor body. (If the solids form a cake, break the solids up using a mortar and pestle so that maximum surface area is available for extraction).
- Charge system with 500 ml toluene and extract in the same manner as previously described.
- Upon completion of the prescribed extraction, remove the flask containing the toluene extract and rinsings of the various soxhlet pieces. Dry the toluene over Na_2SO_4 and concentrate to ~ 1 ml at 75°C by rotary evaporation.
- Combine the extracts (from the solids and the aqueous acid-treatment step) and proceed to sample clean-up.

b) Bottom Ash

- If the sample appears to be inhomogenous, grind to 60/80 mesh in a mortar and pestle. Weigh out a representative sample and proceed in the same manner as fly ash.

c) Filters

- Cut the filter up using a clean scalpel on a petric dish and proceed as in section 'A' above.

d) Amberlite

- Allow the cartridge containing amberlite to air dry overnight in a fume hood.
- Empty amberlite directly into soxhlet body and start soxhlet extraction in the same manner as described in section 'A'.

8.1.2 Liquid Samples.

a) Water

- Transfer sample to an appropriate separatory funnel, rinse container with DI water and small volumes of CH_2Cl_2 into the separatory funnel.
- Extract with 100 ml (or $1/10 \times$ volume of sample), 50 ml x 2 CH_2Cl_2 vigorously for 1 min.
- Drain organic layer (bottom) through Na_2SO_4 into a flask each time. Add 1 ml isooctane and concentrate to ~1 ml at ~30°C.

b) Ethylene Glycol

- Empty sample into a separatory funnel. Rinse the container with DI water, followed by hexane to complete the transfer.
- Add one-half glycol volume of DI water to the sample and mix.
- Extract with 100 ml hexane (or $1/5 \times$ volume of diluted sample) vigorously for 1 min. Drain the bottom layer (glycol) into the original container. Upon completion, add a few ml H_2O into the separatory funnel and let it drain into the container. Allow 1/2 ml hexane to run down the stem of the separatory funnel (thereby cleaning the stem) and combine with the glycol sample.
- Drain the hexane extract through a bed of Na_2SO_4 into a flask.
- Transfer the glycol sample back to the separatory funnel. Repeat extraction two more times.
- Combine the hexane extracts, add 1 ml isooctane and concentrate to ~1 ml at ~35°C.

c) Organic Solution

- Simply dry the sample by passage through Na_2SO_4 and concentrate to ~1 ml.

d) Samples Containing Two Phases

- For phases such as organic/water or organic/glycol, transfer sample to a separatory funnel.
- Dry organic phase by passing it through a prewashed bed of Na_2SO_4 and concentrate to small volume.
- Perform appropriate liquid/liquid extraction on the other layer as described in section 8.1.2 A or 8.1.2 B.

e) Samples with Suspended Solids

- Filter sample through a bed of pre-washed glasswool. If the amount of solids are appreciable, they are soxhlet-extracted. Small amount of solids can simply be shaken with CH_2Cl_2 several times and added to the bulk of the organic solution.

8.2 Sample Clean-up

8.2.1 Chemically Modified Adsorbent with H_2SO_4 on Silica and NaOH on Silica.

- Insert a plug of glass-wool into the Acid/Base Column as a bed support.
- Weigh the following reagents into the column: 1 g silica (bottom layer), 2 g 33% 1M NaOH on silica, 1 g silica, 4 g 44% CH_2SO_4 on silica, 2 g silica and finally approx. 1 g Na_2SO_4 at the top of column.
- Pre-wash the packed column with 30 ml hexane and discard the washing.
- Using a pasteur pipette, transfer the concentrated sample extract quantitatively into the column by 5 ml x 3 hexane rinses of the flask.
- Pass an additional 40 ml hexane through the column. Collect all effluent in a 250 ml flask and concentrate to ~2 ml at 35°C.

8.2.2 Classical Adsorbent Column Chromatography Using Silver Nitrate on Silica and Basic Alumina.

- Pack the AgNO_3 column with 1.5 g 10% AgNO_3 on silica and pre-wash with 15 ml hexane.
- Pack the alumina column with 2.5 g of freshly prepared alumina and pre wash with 10 ml hexane.
- When the AgNO_3 column has drained, position over the alumina column reservoir.
- Transfer sample residue quantitatively into AgNO_3 column by 5 ml x 3 hexane rinses.

- Pass an additional 15 ml x 2 hexane through the system. When drained, the top column is discarded.
- When the hexane has drained to bed level in the alumina column, 20 ml freshly prepared 1.5% CH_2Cl_2 in hexane is passed through. This fraction, containing chlorinated benzenes and PCB, is collected in a 250 ml flask.
- Introduce 30 ml freshly prepared 50% CH_2Cl_2 in hexane (1:1) into the column; collect the effluent in a 250 ml flask. This fraction, containing PCDD/PCDF, is evaporated to ~1 ml at 30°C. Sample clean-up is completed at this stage.
- The sample residue is transferred quantitatively into a clean sample vial and purged to dryness under a gentle stream of nitrogen. Complete the transfer with 0.5 ml x 3 hexane rinses.
- The vial containing the dried sample is tightly capped and stored at -4°C. Reconstitute to volume (usually 0.1 ml) just prior to analysis by the addition of toluene or isooctane.

9 QUALITY ASSURANCE

A minimum of 20% of samples are spiked with labelled TCDD ($^{37}\text{Cl}_4$ - TCDD) or/and OCDD ($^{13}\text{C}_8$ - OCDD) to evaluate the recovery efficiencies from extraction to the analytical finish up. With each batch (6-12) of samples processed, one blank and one standard mixture are included to monitor the performance of sample extraction/clean-up.

Furthermore, a minimum of 20% of sample extracts are analysed in duplicate to demonstrate the precision of analytical instrumentation.

APPENDIX 6

LABORATORY RESULTS

COMBINED SAMPLE IN pg/SAMPLE (ppt)

NOVEMBER SURVEY

Combined No.		TETRA		PENTA		HEXA		HEPTA		OCTA		TOTAL	
		T ₄ COO	T ₄ CDF	P ₅ COO	P ₅ CDF	H ₆ COO	H ₆ CDF	H ₇ COO	H ₇ CDF	O ₈ COO	O ₈ CDF	PCOO	PCDF
51	(9,10,11)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
52	(12,13,14)	N.D.	2	N.D.	2	2	N.D.	N.D.	N.D.	N.D.	N.D.	2	4
53	(15,16)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
54	(19,20,21)	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
55	(22,23)	N.D.	N.D.	2	2	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	2	2
56	(24,25,26)	N.D.	3	N.D.	2	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	5

N.D.: Not detected, detection limit. GC/MS = 2 pg

MONTREAL INCINERATOR SURVEY

Filters, in picograms (10⁻¹² gm)/sample. (ppt)

NOVEMBER SURVEY

Sample No.	TETRA		PENTA		HEXA		HEPTA		OCTA		TOTAL	
	I ₄ CDD	I ₄ CDF	P ₅ CDD	P ₅ CDF	H ₆ CDD	H ₆ CDF	H ₇ CDD	H ₇ CDF	OCDD	OCDF	PCDD	PCDF
30	2	2	13	20	3	12	3	8	5	5	26	47
41	3	2	2	2	3	2	2	2	2	2	12	10

Pico gm/sample (ppt)

NOVEMBER SURVEY

[illegible]

NOVEMBER SURVEY

4 D.

FLYASH IN ng (10⁻⁹)/gm (ppb)

NOVEMBER SURVEY

Sample No.	TETRA		PENTA		HEXA		HEPTA		OCTA		TOTAL	
	T ₄ COO	T ₄ CDF	P ₅ COO	P ₅ CDF	H ₆ COO	H ₆ CDF	H ₇ COO	H ₇ CDF	OCDO	OCDF	PCDO	PCDF
17	5	51	16	30	16	17	25	8	14	1	76	107
18	3	15	4	9	13	9	17	11	22	6	59	50
27	11	61	17	31	32	31	34	17	60	9	154	149
28	6	51	11	29	27	29	30	15	106	6	180	130
38	5	44	16	34	21	23	28	16	80	9	150	126
39	7	53	11	22	26	22	21	13	60	7	129	117
48	8	68	14	32	31	33	37	18	92	10	182	161
49	22	38	8	7	21	12	28	16	37	5	116	78

STACK SAMPLES (QR SERIES) TEST NO. 1

(in picograms - 10^{-12} gm) (ppt)

MARCH SURVEY

Sample No.	TETRA		PENTA		HEXA		HEPTA		OCTA		TOTAL	
	I ₄ ODD	I ₄ ODF	P ₅ ODD	P ₅ ODF	H ₆ ODD	H ₆ ODF	H ₇ ODD	H ₇ ODF	OODD	OODF	PCDD	PCDF
9-10-11	48	32	33	23	13	13	26	24	83	26	203	118
12	272	850	185	618	329	140	216	51	165	44	1167	1703
13	13	23	17	31	13	12	12	11	20	8	75	85
14	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
15	11	5	8	3	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	19	8
16	42	33	11	13	21	17	51	48	122	18	247	129

QR TEST NO. 2

MARCH SURVEY

Sample No.	TETRA		PENTA		HEXA		HEPTA		OCTA		TOTAL	
	T ₄ COO	T ₄ COF	P ₅ COO	P ₅ COF	H ₆ COO	H ₆ COF	H ₇ COO	H ₇ COF	OCOO	OCOF	PCOO	PCOF
17+18+19	N.D.	N.D.	N.D.	N.D.	5	3	6	6	16	N.D.	27	9
20+21+22	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	5	7	18	2	23	9
23+24	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	8	N.D.	8	N.D.

MARCH SURVEY

[illegible]

QR TEST NO. 4

MARCH SURVEY

Sample No.	TETRA		PENTA		HEXA		HEPTA		OCTA		TOTAL	
	T ₄ COO	T ₄ COF	P ₅ COO	P ₅ COF	H ₆ COO	H ₆ COF	H ₇ COO	H ₇ COF	OCOO	OCOF	PCOO	PCOF
33+34+35	8	3	12	6	51	8	42	11	203	28	316	56
36+37+38	93	101	181	163	81	69	187	103	338	60	880	496
39+40	11	8	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	3	N.D.	14	8

MARCH SURVEY

[illegible]

QR TEST NO. 6

MARCH SURVEY

Sample No.	TETRA		PENTA		HEXA		HEPTA		OCTA		TOTAL	
	T ₄ COO	T ₄ CDF	P ₅ COO	P ₅ CDF	H ₆ COO	H ₆ CDF	H ₇ COO	H ₇ CDF	OCOO	OCDF	PCOO	PCDF
49+50+51	120	451	140	344	504	190	370	62	430	93	1564	1140
52+53+54	48	220	72	212	123	435	306	197	333	71	882	1135
55+56	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	8	7	5	7	13

MARCH SURVEY

QR TEST NO. 8

MARCH SURVEY

Sample No.	TETRA		PENTA		HEXA		HEPTA		OCTA		TOTAL	
	T ₄ CDD	T ₄ CDF	P ₅ CDD	P ₅ CDF	H ₆ CDD	H ₆ CDF	H ₇ CDD	H ₇ CDF	OCDD	OCDF	PCDD	PCDF
65+66+67	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
68+69+70	122	43	152	77	154	74	99	34	214	54	741	282
71+72	16	14	18	11	11	6	7	3	4	N.D.	56	34

QR ASH SAMPLE

in pico (10⁻¹²) gm/gm sample (ppt)

MARCH SURVEY

Sample No.	Poids total (mg)	TETRA		PENTA		HEXA		HEPTA		OCTA		TOTAL	
		T ₄ COO	T ₄ COF	P ₅ COO	P ₅ COF	H ₆ COO	H ₆ COF	H ₇ COO	H ₇ COF	OCOO	OCOF	PCOO	PCOF
73	36.0	N.D.	N.D.	N.D.	N.D.	0.3	0.1	0.2	0.1	1.2	0.2	1.7	0.4
74	43.4	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
75	29.3	2.2	2.4	3.9	1.8	1.2	0.4	2.7	0.5	2.2	0.3	12.2	5.4
76	30.1	2.7	1.8	3.7	2.1	13.6	6.8	16.9	5.1	15.7	2.4	52.6	18.2

APPENDIX 7

PCDD AND PCDF CONCENTRATIONS

IN PARTICULATE AND GASEOUS FORM

PCDD Concentration
in particulate and gaseous form
in combustion gases
(pg/m³ ref. dry) (corrected to 12 % CO₂)

November 1982

Test	1		2		3		4	
	Particulate	gaseous	Particulate	gaseous	Particulate	gaseous	Particulate	gaseous
T ₄ CDD	N.D.	N.D.	N.D.	N.D.	1,6	N.D.	2,2	N.D.
P ₅ CDD	N.D.	N.D.	N.D.	1,4	10,2	1,6	2,9	N.D.
H ₆ CDD	N.D.	1,8	N.D.	N.D.	2,3	4,7	4,3	N.D.
H ₇ CDD	N.D.	N.D.	N.D.	N.D.	2,3	6,3	2,9	N.D.
OCDD	N.D.	N.D.	N.D.	N.D.	3,9	1,6	1,4	N.D.
Total PCDD	N.D.	1,8	N.D.	1,4	20,3	14,2	13,7	N.D.
Total PCDD (part. + gas.)		1,8		1,4		34,5		13,7

PCDF Concentration
in particulate and gaseous form
in combustion gases
(pg/m³ ref. dry) (corrected to 12 % CO₂)

November 1982

Test	1		2		3		4	
	Particulate	gaseous	Particulate	gaseous	Particulate	gaseous	Particulate	gaseous
T ₄ CDF	N.D.	1,8	N.D.	2,1	1,6	N.D.	1,4	2,9
P ₅ CDF	N.D.	1,8	N.D.	2,8	15,7	3,1	3,6	N.D.
H ₆ CDF	N.D.	N.D.	N.D.	N.D.	9,4	5,5	3,6	N.D.
H ₇ CDF	N.D.	N.D.	N.D.	N.D.	6,3	6,3	2,9	N.D.
OCDF	N.D.	N.D.	N.D.	N.D.	3,9	1,6	1,4	N.D.
Total PCDF	N.D.	3,6	N.D.	4,9	36,9	16,5	12,9	2,9
Total PCDF (part. + gas.)		3,6		4,9		53,4		15,8

PCDD Concentration
in particulate and gaseous form
in combustion gases
(pg/m³ ref. dry) (corrected to 12 % CO₂)

March 1983

Test	1		2		3		4		5		6		7		8	
	Part.	gas.	Part.	gas.	Part.	gas.	Part.	gas.	Part.	gas.	Part.	gas.	Part.	gas.	Part.	gas.
T ₄ CDD	40	280	N.D.	N.D.	18	27	5	65	34	8	81	32	5	N.D.	N.D.	122
P ₅ CDD	27	183	N.D.	N.D.	33	40	8	114	25	24	94	49	2	1	N.D.	151
H ₆ CDD	11	300	4	N.D.	11	71	32	51	21	13	340	83	1	N.D.	N.D.	164
H ₇ CDD	21	231	5	4	21	103	26	117	35	36	249	206	4	N.D.	N.D.	94
OCDD	69	254	13	21	121	500	127	214	84	93	290	229	38	6	3	194
Total PCDD	168	1248	22	25	204	741	198	561	199	174	1054	599	50	7	3	707
Total PCDD (part.+gas.)	1416		47		945		759		373		1653		57		710	

PCDF Concentration
in particulate and gaseous form
in combustion gases
(pg/m³ ref. dry) (corrected to 12 % CO₂)

March 1983

Test	1		2		3		4		5		6		7		8	
	Part.	gas.	Part.	gas.	Part.	gas.	Part.	gas.	Part.	gas.	Part.	gas.	Part.	gas.	Part.	gas.
T ₄ CDF	27	754	N.D.	N.D.	10	20	2	68	33	6	304	148	8	2	N.D.	51
P ₅ CDF	19	550	N.D.	N.D.	36	23	4	102	21	17	232	143	3	1	N.D.	78
H ₆ CDF	11	140	2	N.D.	8	28	5	43	18	7	128	293	2	N.D.	N.D.	71
H ₇ CDF	20	91	5	6	15	34	7	65	33	12	42	138	3	N.D.	N.D.	33
OCDF	22	58	N.D.	1	7	53	17	38	23	19	63	51	3	N.D.	2	48
Total PCDF	97	1593	7	7	76	158	35	316	128	61	769	773	19	3	2	281
Total PCDF (part.+gas.)	1690		14		234		351		189		1542		22		283	

